JOURNAL OF
THE ASIATIC SOCIETY OF BANGLADESH
SCIENCE

ISSN 1016-6947

Vol. 43 | No. 2 | December 2017

THE ASIATIC SOCIETY OF BANGLADESH

THE ASIATIC SOCIETY OF BANGLADESH

Journal of the Asiatic Society of Bangladesh, Science is published twice a year (June and December comprising one volume) in English. Original research papers dealing with all branches of science with special reference to Asiatic studies by the members of the Society are published. Any non-member of the Society may publish a research paper if it is communicated by a member of the Society.

SUBSCRIPTION

Annual per volume:			Single issue:		
Inland	:	Tk. 500.00	Inland	:	Tk. 250.00
Foreign	:	$ 40.00	Foreign	:	$ 20.00

CORRESPONDENCE

All correspondence should be addressed to The General Secretary, The Asiatic Society of Bangladesh, 5 Old Secretariat Road (Nimtali), Ramna, Dhaka-1000, Bangladesh.
Phone : 9576391, E-mail : asiaticsociety.bd@gmail.com, www.asiaticsociety.org.bd

PUBLISHED BY

The Asiatic Society of Bangladesh

PRINTED AT

Rita Art Press
13/KA/1/1, K. M. Das Lane, Tikatuly, Dhaka-1203

JOURNAL OF
THE ASIATIC SOCIETY OF BANGLADESH
SCIENCE
(J. Asiat. Soc. Bangladesh, Sci.)

Vol. 43 **No. 2** **December 2017**

CONTENTS

Guidelines to authors

The Journal of the Asiatic Society of Bangladesh publishes original research papers related to any field of sciences from any where in the world.

All manuscripts written in English and typed on a good quality bond paper (A4) with double space and sufficient marwgins should be submitted to the Editor with CD. Regarding publication of the paper after review, the decision of the Editorial Board shall be final. All accepted papers by the Editorial Board are subjected to editorial changes.

The manuscript of a full paper, preferably be limited within ten typed pages (A4) including tables, figures, graphs, references etc. For short communication it should not exceed four pages (approximately 900 words).

The manuscript should contain the following sub-titles in sequence: Title, Abstract, Key words, Introduction, Materials and Methods, Results and Discussion, Acknowledgements, if any, and References. In case of **'Short Communication'** no subtitles are necessary.

Title: It should be brief and specific. The manuscript will have a separate title page giving name of the paper, authors name and address and a running head.

Abstract: It should not exceed 150 words containing the gist of results only.

Key words: Should not exceed 6 words and it should be after Abstract.

Text: The text of the article should be clear and precise. Introduction should be concise, precise and relevant to the study. Methods already published should be indicated by references. In case of modifications of a method give explicit descriptions. Results should be stated concisely and presented logically referring to tables and graphs. Data of tables and graphs should not be repeated in the text. Simple data may be presented as a text instead of Tables and Figs. Each result should be followed by discussion or interpretation (in any case the Results and Discussion must not be separated) with appropriate reference(s). Discussion should deal with the obtained results and related results published nationally and internationally. Concluding remarks (without heading) must be given (that tally with the objective) in the last paragraph. The references in the text should be arranged chronologically.

Tables, Graphs and Figures: Number of tables, graphs and figures should be minimum. However, these should be typed separately. The graphs and figures should be drawn giving statistical analysis, with Indian ink on tracing papers and properly labelled. The figures and graphs should be properly drawn with bold, solid lines so that these could be reduced up to half or less of the original. The photographs should be submitted on glossy papers. Symbols in the graphs should be distinct and labels should be readable.

The photographs should be submitted on glossy paper or in JPEG format. Black and white and coloured photographs are accepted.

References: In the text, references should be cited within brackets quoting author's surname and the year of publication in the appropriate place e. g. (Bhuiyan 1964), Khan and Rahman 1970 and Khan *et al*. 1970). Two or more references when put within the same bracket, they should be separated by a comma. References should be arranged alphabetically according to author's surname at the end of the paper. Names of journals and books should be in italics giving edition, year of publication and name of the publishers. Examples:

Amin, F.B., Z.N. Tahmida Begum and R. Mandal, 2011. Impact of Potassium and zinc on growth of cyanobacteria in seasonally flooded rice field of Meghna floodplain. *J. Asiat. Soc. Bangladesh, Sci*. **37**(2): 251-255.

Khan, M.S. 1991. Angiosperms. In: *Two Centuries of Plant Sciences in Bangladesh and Adjacent Regions* (ed. A.K.M. Nurul Islam). pp. 175-194, Asiatic Soc. Bangladesh. Dhaka.

Bhuiyan, A.L. 1964. *Fishes of Dacca.* Asiatic Society of Bangladesh, Dhaka. 148 pp.

The author(s) must submit one computer composed hard copy of the revised paper along with the CD in MS Word version.

Final galley proofs, if possible, will be sent to authors. No alternations or additions in the text are desirable at this stage.

Off-prints

A contributor of each paper is entitled to get 10 off-prints free of cost.

Declaration

While submitting a paper the individual authors are to sign a declaration to the effect that (i) the work reported has been carried out by them and they jointly prepared the manuscript; (ii) they take public responsibility for the contents of the paper; (iii) the paper has not been published before in any referred scientific journal or has not been submitted to such journal for publication.

Review of books

Books for review should be sent to the Editor in duplicate.

THE ASIATIC SOCIETY OF BANGLADESH
Council 2016 & 2017

J. Asiat. Soc. Bangladesh, Sci. 43(2): 143-159, December 2017

DIVERSITY OF ANGIOSPERM FLORA OF KUAKATA NATIONAL PARK, PATUAKHALI DISTRICT, BANGLADESH

M. AZIZAR RAHAMAN[1], MD. AZIZUR RAHMAN[2] AND
MOHAMMAD ZASHIM UDDIN[3]
[1]*Wildlife Center, Ban Bhaban, Mohakhali, Dhaka-1212, Bangladesh*
[2]*Department of Botany, Chittagong University, Bangladesh*
[3]*Department of Botany, Dhaka University, Bangladesh*

Abstract

The article mainly highlights the angiosperm diversity of Kuakata National Park (KNP) of Patuakhali district. Angiosperm diversity assessment in the park was conducted in between 2015 and 2016. A total of 265 plant species belonging to 75 families and 204 genera was identified from this National Park. Tree species of the park are represented by 89, shrubs by 45, herbs by 94, climbers by 31 and epiphytes by 6 species. In Magnoliopsida (dicots), Fabaceae is the largest family represented by 14 species, whereas in Liliopsida (monocots), Poaceae is the largest family represented by 13 species. The plant species recorded from the National Park were distributed in different habitats and maximum species were recorded in plantation areas(108) followed by homesteads (61), cultivated land(38), roadsides (35) and mangrove areas (23).The study has reported the presence of medicinal plants, wildlife supporting plants, exotics and invasive plants and rare plants in park. The presence of edible species in the National Park is very rare. The introduction of exotics species into the National Park has been accepted. As the presence of exotics in park, local flora will be faced great challenges in future for their existence. This article also focused conservation values, management concerns and some actions for conservation of angiosperm diversity in the National Park. The present angiosperm diversity assessment in the park is very preliminary and based on this sound conclusion cannot be made yet.

Key words: Diversity, Angiosperm flora, Kuakata national park, Patuakhali district, Bangladesh

Introduction

Kuakata National Park (KNP) is the 12thdeclared National Park of Bangladesh and a part of the Reserved Forest of Patuakhali Coastal Forest Division. Initially it was declared as an Eco-Park in 2005. Later Kuakata Eco-Park was gazetted as a National Park in 2010 (Gazette notification of Ministry of Environment and Forests no. MoEF/Forest Section-2/02/National Park/10/2010/509, Dated: 24/10/2010 as per power given under the provisions of Article 23 (3) of the Bangladesh Wildlife (Preservation) (Amendment) Act 1974). It is situated in the southern part of Bangladesh under Kalapara *Upazila* of Patuakhali district and geographical location is in between including *21°49′16″*N and *90°07′11″*E. The park is bordered by the Bay of Bengal to the east, south and west

[1]Corresponding author : E-mail:alam027456@gmail.com

including the Andharmanik River and WAPDA embankment to the north. The National Park has an area of 1613 ha with Gangamati, Khajura and Kuakata forest beats on the seashore, comprises coastal mangrove plantations (BFD 2012).

Kuakata National Park enjoys tropical maritime climate characterized by high rain during monsoon. The average temperature of KNP ranges between 21.71°C to 29.41° C and average annual rainfall is about 2657 mm/year. The soil of the area consists of calcareous alluvium, acid phosphate soil, grey floodplain and grey piedmont soils. These soils are saline and the P^H values are neutral to slightly alkaline. KNP frequently was affected several serious cyclones during last couples of years. The park area is experiencing rapid erosion mainly at the south and west parts and is more threatened due to regular sea wave actions (BFD 2006).

The diversity of plants is very much essential in shaping of human civilization in recent days. Unfortunately, such diversity has been eroding in alarming rate from the nature before evaluation and documentation. At the end of 19 th century the head of states from all over the world had realized this burning issue. In 1992 world leaders in Earth Summit in Rieo De Janerio formulated biodiversity conservation policy including agenda 21 which had also given importance on the documentation and sustainable utilization of traditional knowledge of plant diversity. After the convention the assessment works of plant diversity in different countries of the world is in progress (Uddin and Abiabdullah 2016). In case of Bangladesh angiosperm diversity assessment of different National Parks and Wildlife Sanctuaries had already been started (Khan *et al.* 1994, Rahman and Hassan 1995, Uddin *et al*. 1998, Uddin and Rahman 1999, Khan and Huq 2001, Uddin *et al.* Uddin and Hassan 2004, 2010; 2011, Uddin *et al*. 2013, 2015, Sajib *et al.* 2015 and Uddin and Abiabdullah 2016). Literature review revealed that so far no work in available on the angiosperm diversity of Kuakata National Park. For the management of the park, baseline data on the angiosperm diversity are essential. In the present study an attempt was taken to achieve the following objectives: (a) to document the angiosperms diversity, (b) to highlights management concerns of the park and (c) to recommend some conservation actions for Kuakata National Park.

Materials and Methods

Extensive floristic survey had been conducted in different seasons of the year of 2015 and 2016 (Hyland 1972, Balick *et al.* 1982 and Alexiades 1996). The study included plantation areas, mangrove areas, cultivated land, roadside and homestead areas. Particular efforts were given to find species of conservation concern including threatened and rare species. Sample size was determined using species area curve or species time curve following Goldsmith and Harrison (1976). Maximum identification of species was done in the field sites and rest of the specimens was collected and processed using standard herbarium techniques (Hyland 1972). Identification was done by consulting

different Floras (Uddin and Hassan 2004, Siddiqui *et al.* 2007 and Ahmed *et al.* 2008a, 2008b, 2009a, 2009b, 2009c, 2009d and 2009e).

The updated nomenclatures of the species are integrated by following Siddiqui *et al.* (2007) and Ahmed *et al.* (2008a, 2008b, 2009a, 2009b, 2009c, 2009d and 2009e). Threatened categories of plants were confirmed with the help of Khan *et al.* (2001) and Ara *et al.* (2013). Some noxious exotic plant species were also identified comparing with the reports of Hossain and Pasha (2004) and Akter and Zuberi (2009). Families were arranged according to Cronquist (1981). Voucher specimens are preserved at Wildlife Center Herbarium (WCH), Bangladesh Forest Department.

Results and Discussion

A total of 265 plant species belonging to75 families and 204 genera was identified from the Kuakata National Park. For each plant species scientific name, local name, family, habit and habitat are presented in Table 1. Among the families, Fabaceae, Poaceae, Caesalpiniaceae, Euphorbiaceae, Malvaceae, Moraceae, Solanaceae, Convolvulaceae, Asteraceae, Apocynaceae, Mimosaceae, Verbenaceae, Amaranthaceae, Cyperaceae, Acanthanceae and Zingiberaceae were found to be most common. By analyzing habit diversity it was found trees by 89, shrubs by 45, herbs by 94, climbers by 31 and epiphytes by 6 species. In Magnoliopsida (dicots), Fabaceae is the largest family represented by 14 species, whereas in Liliopsida (monocots), Poaceae is the largest family represented by 13 species. The plant species recorded from the National Park was scattered in different habitats. Among the habitats, maximum species were recorded in plantation areas (108) followed by homesteads (61), cultivated land (38), roadsides (35) and mangrove areas (23). Most of the plant species in the plantation areas, homesteads and roadsides were introduced by the forest department and local people. The number of edible plants was found minimum in the park.

During the study, much concentration was given in the following habitats: The mangrove plantations were developed all around the National Park. Each year the newly accreted lands facing to the sea were undertaken by the forest department for plantation programs. The top canopy in the mangrove was occupied by *Sonneratia apetala, S. caselaoris, Avicennia officinalis, Excoecaria agallocha* and *Bruguiera gymnorrhiza.* Besides few representations of *Heritiera fomes* and *Ceriops decandra* were also detected in the park. The forest ground was covered mainly by the seedlings of *Ex. agallocha, S. apetala* and *A. officinalis.* In the forest periphery, the bush forming dominant species were *Acanthus ilicifolius, Nipa fruticans* and *Ex. agallocha.* The ground near the intertidal zone was mainly dominated by *Pandanus foetidus, Phragmites karka* and *Saccharum spontaneum.* Most common climbers in the mangrove forest were *Derris scandens, D. trifolia, Ipomoea pes-caprae, Ichnocarpus frutescens* and *Desmodium heterocarpon.* Some members of sedge species including *Cyperus diformis* and *C. kyllingia* were observed in this zone. The banks of the tidal zone were dominated by a good number of tree species

Table 1. Angiosperms diversity of Kuakata National Park.

Scientific name	Family	Local name	Habit	Habitat
Ablemoschus esculentus (L.) Moench	Malvaceae	Vendi	Herb	Homestead
Abroma augusta (L.) L.f.	Sterculiaceae	Ulatkambal	Tree	Plantation areas
Abrus precatorius L.	Fabaceae	Ratti	Climber	Plantation areas
Abutilon indicum (L.) Sweet	Malvaceae	Abtilun	Shrub	Roadside
Acacia auriculiformis A.Cunn. ex Benth. & Hook.	Mimosaceae	Akashmoni	Tree	Plantation areas
Acacia farnesiana (L. f.)Willd.	Mimosaceae	Khaia babla	Tree	Plantation areas
Acacia mangium Willd.	Mimosaceae	Belgium	Tree	Plantation areas
Acacia nilotica L.	Mimosaceae	Babla	Tree	Plantation areas
Acanthus ilicifolius L.	Acanthaceae	Hergoza	Shrub	Mangrove areas
Achyranthes aspera L.	Amaranthaceae	Apang	Herb	Homestead
Adenanthera pavonina L.	Mimosaceae	Raktakambal	Tree	Homestead
Adhatoda zeylanica Mdikus	Acanthaceae	Bashak	Shrub	Homestead
Aegle marmelos (L.) Corr.	Rutaceae	Bel	Tree	Homestead
Aerides multiflora Roxb.	Orchidaceae	Aerid	Epiphyte	Plantation areas
Aerides odorata Lour.	Orchidaceae	Aerid	Epiphyte	Plantation areas
Ageratum conyzoides L.	Asteraceae	Fulkuri	Herb	Roadside
Albizia lebbeck (L.)Benth. & Hook.	Mimosaceae	Kalo koroi	Tree	Roadside
Albizia lucidior (Steud.) Nielsen	Mimosaceae	Koroi	Tree	Homestead
Albizia procera(Roxb.) Benth.	Mimosaceae	Sil-koroi	Tree	Roadside
Allamanda cathartica L.	Apocynaceae	Allamanda	Herb	Plantation areas
Allophylus cobbe (L.) Raeuschel	Sapindaceae	Chita	Shrub	Plantation areas
Alocasia macrorrhizos (L.) G. Don	Araceae	Mankachu	Herb	Homestead
Alstonia scholaris L.	Apocynaceae	Chatim	Tree	Plantation areas
Alternanthera philoxeroides (Mart.) Griseb.	Amaranthaceae	Helencha	Herb	Cultivated land
Amaranthus lividus L.	Amaranthaceae	Gobura notey	Herb	Roadside
Amaranthus spinosus L.	Amaranthaceae	Kanta-nutia	Herb	Roadside
Amaranthus viridis L.	Amaranthaceae	Notey sak	Herb	Homestead
Amorphophallus bulbifer (Roxb.) Blume	Araceae	Oll	Herb	Homestead
Andrographis paniculata (Burm.f.)Wall.*ex* Nees	Acanthaceae	Kalo megh	Herb	Homestead
Annona reticulata L.	Annonaceae	Ata	Tree	Homestead
Anthocephalus cadamba (Roxb.) Miq.	Rubiaceae	Kadam	Tree	Plantation areas

Scientific name	Family	Local name	Habit	Habitat
Aphanamixis polystachya (Wall.) R. N. Parker	Meliaceae	Pitraj	Tree	Plantation areas
Areca catechu L.	Arecaceae	Supari	Tree	Homestead
Artocarpus chaplasha Roxb.	Moraceae	Chapalish	Tree	Plantation areas
Artocarpus heterophyllus Lamk.	Moraceae	Kanthal	Tree	Homestead
Averrhoa bilimbi L.	Oxalidaceae	Bilimbi	Tree	Homestead
Averrhoa carambola L.	Oxalidaceae	Kamranga	Tree	Homestead
Avicennia alba Blume	Verbenaceae	Sada baen	Tree	Mangrove areas
Avicennia marina (Forssk.) Vierh.	Verbenaceae	Moricha baen	Tree	Mangrove areas
Avicennia officinalis L.	Verbenaceae	Kala baen	Tree	Mangrove areas
Azadirachta indica A. Juss.	Meliaceae	Neem	Tree	Homestead
Bacopa monnieri (L.) Pennell	Scrophulariaceae	Brammi	Herb	Cultivated land
Bambusa tulda Roxb.	Poaceae	Mitting bash	Tree	Homestead
Barringtonia acutangula (L.) Gaertn.	Lecythidaceae	Hizol	Tree	Mangrove areas
Bauhinia purpurea L.	Caesalpiniaceae	Kanson	Tree	Plantation areas
Blumea lacera (Burm. f.) DC.	Asteraceae	Kukurmuta	Herb	Cultivated land
Blumea membranacea Wall. *ex*DC.	Asteraceae	Shialutra	Herb	Cultivated land
Bombax ceiba L.	Bombacaceae	Shimul	Tree	Plantation areas
Borassus flabellifer L.	Arecaceae	Tal	Tree	Homestead
Bridelia retusa (L.) A. Juss.	Euphorbiacea	Kata koi	Shrub	Plantation areas
Bruguiera gymnorhiza (L.) Lamk.	Rhizophoraceae	Kakra	Tree	Mangrove areas
Butea monosperma (Lamk.) Taub.	Fabaceae	Polash	Tree	Plantation areas
Caesalpinia pulcherrima (L.) Swartz	Caesalpiniaceae	Radhachura	Tree	Plantation areas
Cajanus cajan (L.) Millsp.	Fabaceae	Orhor	Shrub	Homestead
Calamus erectus Roxb.	Arecaceae	Kadam Bet	Shrub	Plantation areas
Calotropis procera (Aiton) Dryand	Asclepiadaceae	Akand	Shrub	Roadside
Calophyllum innophyllum L.	Clusiaceae	Punnal	Tree	Plantation areas
Calycopteris floribunda (Roxb.) Lamk.	Combretaceae	Guicha lata	Climber	Plantation areas
Carica papaya L.	Caricaceae	Pepe	Shrub	Homestead
Cassia alata L.	Caesalpiniaceae	Dadmordan	Shrub	Roadside

Scientific name	Family	Local name	Habit	Habitat
Cassia fistula L.	Caesalpiniaceae	Sonalu	Tree	Plantation areas
Cassia tora L.	Caesalpiniaceae	Tora	Herb	Roadside
Cassia siamea Lamk.	Caesalpiniaceae	Minjiri	Tree	Plantation areas
Casuarina equisetifolia Forst.	Casuarinaceae	Jhau	Tree	Plantation areas
*Celosia cristata*L.	Amaranthaceae	Morogful	Herb	Cultivated land
Centella asiatica (L.) Urban	Apiaceae	Thankoni	Herb	Cultivated land
Ceriops decandra (Griff.) Ding. Hou	Rhizophoraceae	Goran	Tree	Mangrove areas
Chrysalidocarpus lutescens (Bory) H. Wendl.	Arecaceae	Areca palm	Shrub	Plantation areas
Chrysopogon aciculatus (Retz.) Trin.	Poaceae	Premkanta	Herb	Roadside
Citrus aurantifolia (Christm.&Panzer) Swingle	Rutaceae	Labu	Shrub	Homestead
Citrus maxima (Burm. F.) Merr.	Rutaceae	Jambura	Tree	Homestead
*Clerodendrum viscosum*Vent.	Verbenaceae	Bhant	Shrub	Roadside
Clitoria ternatea L.	Fabaceae	Aparjita	Climber	Homestead
Coccinia grandis(L.) Voigt	Cucurbitaceae	Telakucha	Climber	Plantation areas
Cocos nucifera L.	Arecaceae	Narikel	Tree	Homestead
Codiaeum variegatum(L.)Rumph *ex* A. Juss.	Euphorbiaceae	Patabahar	Shrub	Plantation areas
Colocasia esculenta (L.) Schott	Araceae	Kachu	Herb	Homestead
Commelina benghalensis L.	Commelinaceae	Kanchira	Herb	Cultivated land
Cosmos bipinnatus Cav.	Asteraceae	Cosmos	Herb	Cultivated land
Costus speciosus (Koenig *ex* Retz.) Smith	Costaceae	Keumul	Herb	Plantation areas
Crinum asiaticum L.	Liliaceae	Crinum	Herb	Mangrove areas
Crotalaria pallida Ait.	Fabaceae	Jhunjhuni	Herb	Roadside
Crotalaria juncea L.	Fabaceae	Jhunjhuni	Herb	Roadside
Croton bonplandianum Baill.	Euphorbiaceae	Croton	Herb	Roadside
Cucurbita maxima Duchesne	Cucurbitaceae	Misti kumra	Climber	Homestead
Curculigo orchioides Gaertn.	Liliaceae	Talmuli	Herb	Plantation areas
Curcuma amada Roxb.	Zingiberaceae	Amada	Herb	Plantation areas
Curcuma domestica Valet.	Zingiberaceae	Holud	Herb	Homestead
Curcuma latifolia Rosc.	Zingiberaceae	Sadi	Herb	Roadside

Scientific name	Family	Local name	Habit	Habitat
Curcuma zedoaria (Christm.) Rosc.	Zingiberaceae	Shoti	Herb	Plantation areas
Cuscuta reflexa Roxb.	Cuscutaceae	Shorna lata	Climber	Roadside
Cymbidium aloifolium (L.) Sw.	Orchidaceae	Churi	Epiphyte	Plantation areas
Cynodon dactylon (L.) Pers.	Poaceae	Durba	Herb	Roadside
Cyperus cyperoides (L.) O. Ktze.	Cyperaceae	Sedge	Herb	Cultivated land
Cyperus iria L.	Cyperaceae	Sedge	Herb	Cultivated land
Cyperus kyllingia Endl.	Cyperaceae	Sedge	Herb	Mangrove areas
Cyperus rotundus L.	Cyperaceae	Mutha grass	Herb	Cultivated land
Dalbergia sissoo Roxb	Fabaceae	Sissoo	Tree	Plantation areas
Datura metel L.	Solanaceae	Dhatura	Shrub	Plantation areas
Delonix regia (Hook) Raf.	Caesalpiniaceae	Krishnachura	Tree	Plantation areas
Dendrobium aphyllum (Roxb.) Fischer	Orchidaceae	Dendrobium	Epiphyte	Plantation areas
Dendrobium nobile Lindl.	Orchidaceae	Dendrobium	Epiphyte	Plantation areas
Derris scandens (Roxb.) Benth.	Fabaceae	Kalilata	Climber	Mangrove areas
Derris trifoliata Lour.	Fabaceae	Mellata	Climber	Mangrove areas
Desmodium heterocarpon (L.) DC.	Fabaceae	-	Climber	Mangrove areas
Dillenia indica L.	Dilleniaceae	Chalta	Tree	Homestead
Dioscorea alata L.	Dioscoreaceae	Jora alu	Climber	Homestead
Dioscorea bulbifera L.	Dioscoreaceae	Bon alu	Climber	Homestead
Dioscorea pentaphylla L.	Dioscoreaceae	-	Climber	Plantation areas
Diospyros malabarica (Desr.) Kostel.	Ebenaceae	Deshigab	Tree	Homestead
Dracaena spicata Roxb.	Agavaceae	Dracaena	Shrub	Plantation areas
Duranta erecta L.	Verbenaceae	Katamehedi	Shrub	Plantation areas
Echinochloa colona (L.) Link	Poaceae	Shama grass	Herb	Cultivated land
Eclipta prostrata (L.) L.	Asteraceae	Keshoraj	Herb	Cultivated land
Eichhornia crassipes (Mart.) Solms	Pontederiaceae	Kachuripana	Herb	Cultivated land
Elaeocarpus tectorius (Lour.) Poir.	Elaeocarpaceae	Jalpai	Tree	Homestead
Enhydra variegata L.	Asteraceae	Helencha	Herb	Cultivated land

Scientific name	Family	Local name	Habit	Habitat
Erythrina indica Lam.	Fabaceae	Mandar	Tree	Plantation areas
Eucalyptus camaldulensis Dehnh.	Myrtaceae	Eucalyptus	Tree	Plantation areas
Euphorbia hirta L.	Euphorbiaceae	Dudhia	Herb	Cultivated land
Euphorbia thymifolia L.	Euphorbiaceae	Dudhia	Herb	Cultivated land
Excoecaria agallocha L.	Euphorbiaceae	Gewa	Tree	Mangrove areas
Ficus benghalensis L.	Moraceae	Bot	Tree	Roadside
Ficus benjamina L.	Moraceae	Jir Dumur	Tree	Plantation areas
*Ficus hispida*L.f.	Moraceae	Dewall	Shrub	Plantation areas
Ficus pumila L.	Moraceae	dumar	Climber	Plantation areas
Ficus racemosa L.	Moraceae	Jagya dumar	Tree	Homestead
Ficus virens Ait.	Moraceae	Pakur	Tree	Roadside
Fimbristylis dichotoma (L.) Vahl	Cyperaceae	-	Herb	Cultivated land
Fimbristylis quinopangularis (Vahl) Kunth.	Cyperaceae	-	Herb	Cultivated land
Garcinia cowa Roxb. Choisy.	Clusiaceae	Kao	Tree	Homestead
Gloriosa superba L.	Liliaceae	Ulatchandal	Climber	Plantation areas
Glycosmis pentaphylla (Retz.) DC.	Rutaceae	Datmajan	Shrub	Roadside
Gmelina arborea Roxb.	Varbenaceae	Gamari	Tree	Plantation areas
Gymnopetalum chinense (Lour.)Merr.	Cucurbitaceae	-	Climber	Homestead
Hedyotis scandens Roxb.	Rubiaceae	Bish lata	Climber	Plantation areas
Heliotropium indicum L.	Boraginaceae	Hatisur	Herb	Cultivated land
Hemidesmus indicus (L.) R. Br. *ex* Schott.	Asclepiadacae	Anantamul	Climber	Plantation areas
Heritiera fomes Buch.-Ham.	Sterculiaceae	Sundari	Tree	Mangrove areas
Hibiscus rosa sinensis L.	Malvaceae	Joba	Shrub	Plantation areas
Hibiscus tilliaceus L.	Malvaceae	Bolla	Shrub	Plantation areas
Hodgsonia macrocarpa (Blume) Cogn.	Cucurbitaceae	Makal	Climber	Plantation areas
Holarrhena antidysenterica (L.) Wall. ex Decne.	Apocynaceae	Kurchi	Shrub	Plantation areas
Hopea odorata Roxb.	Dipterocarpaceae	Telsur	Tree	Homestead

Scientific name	Family	Local name	Habit	Habitat
Hoya prasitica (Roxb.) Wall. ex Wight	Apocynaceae	Hoya	Climber	Roadside
Hyptis suaveolens (L.) Poit.	Lamiaceae	Tokma	Herb	Roadside
Ichnocarpus frutescens (L.) W.T.Alton	Apocynaceae	Shamalata	Climber	Mangrove areas
Imperata cylindrica (L.) Raeusch.	Poaeae	Ulu	Herb	Roadside
Ipomoea aquatica Forssk.	Convolvulaceae	Kalmi	Climber	Homestead
Ipomoea batata (L.) Lamk.	Convolvulaceae	Misti alu	Climber	Homestead
Ipomoea fistulosa Mart. *ex* Choisy	Convolvulaceae	Dholkalmi	Shrub	Roadside
Ipomoea pes-caprae (L.) R. Br.	Convolvulaceae	Chagalkhuri	Climber	Mangrove areas
Ischaemum polytrias indica (Houtt.) Veldkamp.	Poaceae	Toto grass	Herb	Cultivated land
Ixora acuminata Roxb.	Rubiaceae	Rangan	Shrub	Plantation areas
Ixora Javanica (Blum) DC.	Rubiaceae	Rangan	Shrub	Plantation areas
Ixora pavetta Andr.	Rubiaceae	Swet rangan	Shrub	Plantation areas
Jatropha gossypiifolia L.	Euphorbiaceae	Lal bharenda	Shrub	Homestead
Justicia simplex D. Don.	Acanthaceae	Jogathmardan	Shrub	Plantation areas
Kyllinga nemoralis (J.R.Forst. & G. Forst.) Dandy ex Hutch&Dalziel	Cyperaceae	Sedge	Herb	Cultivated land
Lablab purpureus (L.) Sweet	Fabaceae	Seem	Climber	Homestead
Lagerstroemia speciosa (L.) Pers.	Lythraceae	Jarul	Tree	Plantation areas
Lannea coromandelica (Houtt.) Merr.	Anacardiaceae	Jiga	Tree	Plantation areas
Lantana camara L.	Verbenaceae	Lantana	Shrub	Plantation areas
Lawsonia inermis L.	Lythraceae	Mehedi	Shrub	Homestead
Leea guineensis G.Don	Leeaceae	Phupharia	Shrub	Plantation areas
Leea macrophylla Roxb.ex Hornem	Leeaceae	Dhol sumundro	Shrub	Plantation areas
Leucas aspera (Willd.) Link	Lamiaceae	Dandakalash	Herb	Roadside
Leucas lavandulaefolia Ress	Lamiaceae	Gaochia	Herb	Roadside
Limnophila indica (L.) Druce	Scrophulariaceae	Pani karpur	Herb	
Limonia acidissima L.	Rutaceae	Koethbel	Tree	Homestead
Lindernia antipoda (L.) Alston	Scrophulariaceae	Lindernia	Herb	Cultivated land
Litsea glutinosa (Lour.) C.B.Rob	Lauraceae	Menda	Tree	Plantation areas
Ludwigia hyssopifolia (G. Don) Excell	Onagraceae	Panilong	Herb	Cultivated land
Ludwigia repens J.R.Forst.	Onagraceae	Mulsi	Herb	Cultivated land
Macrosolen cochinchinensis (Lour.) Tiegh.	Loranthaceae	Porgassa	Herb	Plantation areas

Scientific name	Family	Local name	Habit	Habitat
Mangifera indica L.	Anacardiceae	Aam	Tree	Homestead
Melastoma malabathricum L.	Melastomataceae	Futki	Shrub	Plantation areas
Melia azedarach L.	Meliaceae	Ghora neem	Tree	Plantation areas
Magnolia champaca (L.)Baill. *ex* Pierre.	Magnoliaceae	Cahmpa	Tree	Plantation areas
Mikania cordata (Burm. f.) B.L.Rob.	Asteraceae	Assamlata	Climber	Plantation areas
Mimosa invisa Colla.	Mimosaceae	Bara lajjabati	Herb	Plantation areas
Mimosa pudica L.	Mimosaceae	Lajjabati	Herb	Roadside
Mimusops elengi L.	Sapotaceae	Bokul	Tree	Homestead
Monochoria vaginalis (Burm. f.) C. Presl	Pontederiaceae	Nukha	Herb	Cultivated land
Moringa oleifera Lamk.	Moringaceae	Sajna	Tree	Homestead
Mucuna pruriens (L.) DC.	Fabaceae	Alkushi	Climber	Plantation areas
Murraya koenigii (L.) Spreng.	Rutaceae	Kamini	Shrub	Plantation areas
Musa paradisiaca L.	Musaceae	Kola	Herb	Homestead
Neolamarckia cadamba (Roxb.) Bosser	Rubiaceae	Kadam	Tree	Homestead
Nerium oleander L.	Apocynaceae	Korobi	Shrub	Plantation areas
Nymphaea rubra Roxb. *ex* Andr.	Nymphaeaceae	Lal shaphla	Herb	Plantation areas
Nypa fruticans Wurmb.	Arecaceae	Golpata	Shrub	Mangrove areas
Ocimum terviflorum L.	Lamiaceae	Tulsi	Herb	Homestead
Opuntia dillenii (Ker Gawl.) Haw.	Cactaceae	Phanimansa	Herb	Plantation areas
Oryza sativa L.	Poaceae	Dhan	Herb	Cultivated land
Oxalis corniculata L.	Oxalidaceae	Amrul	Herb	Cultivated land
Pandanus foetidus Roxb.	Pandanaceae	Keya kanta	Herb	Mangrove areas
Panicum notatum Retz.	Poaceae	Panicum	Herb	Cultivated land
Paspalum distichum L.	Poaceae	Gitlaghas	Herb	Cultivated land
Passiflora foetida L.	Passifloraceae	Jhumka lata	Climber	Plantation areas
Polygonum pubescens Blume	Polygonaceae	Bish kata	Herb	Plantation areas
Polygonum hydropiper (L.) Delarbne	Polygonaceae	Lal-kukri	Herb	Cultivated land
Phoenix sylvestris (L.) Roxb.	Arecaceae	Khejur	Tree	Homestead

Scientific name	Family	Local name	Habit	Habitat
Phragmites karka (Retz.) Trin.*ex* Steud	Poaceae	Nol	Herb	Mangrove areas
Phyllanthus emblica L.	Euphorlsiaceae	Amlaki	Tree	Homestead
Physalis minima L.	Solanaceae	Fotka	Herb	Plantation areas
Piper longum L.	Piperaceae	Pipul	Climber	Homestead
Plumeria alba L.	Apocynaceae	Katgolap	Tree	Plantation areas
Pongamia pinnata (L.) Pierre	Caesalpiniaceae	Koroj	Tree	Plantation areas
Pothos scandens L.	Araceae	Batilata	Climber	Plantation areas
Premna esculenta Roxb.	Verbenaceae	Lallong	Shrub	Plantation areas
Psidium guajava L.	Myrtaceae	Piyara	Tree	Homestead
Pterospermum acerifolium (L.)Willd.	Sterculiaceae	Muskunda	Tree	Plantation areas
Rhizophora mucronata Lam.	Rhizophoraceae	Rhizophora	Tree	Plantation areas
Rhynchostylis retusa (L.) Blume	Orchidaceae	Foxtail	Epiphyte	Plantation areas
Ricinus communis L.	Euphorbiaceae	Reri	Herb	Homestead
Saccharum spontaneum L.	Poaceae	Kash	Herb	Mangrove areas
Albizia saman (Jacq.) Merr.	Mimosaceae	Randi korai	Tree	Plantation areas
Saraca thaipingensis Prain	Caesalpiniaceae	Ashok	Tree	Plantation areas
Schumannianthus dichotomus (Roxb.) Gagnep.	Marantaceae	Patipata	Herb	Homestead
Scindapsus officinalis (Roxb.) Schott	Araceae	Money plant	Herb	Plantation areas
Scoparia dulcis L.	Scrophulariaceae	Bandhuni	Herb	Roadside
Sesbania grandiflora (L.) Pers.	Fabaceae	Bakul ful	Shrub	Homestead
Senna alata (L.) Roxb.	Caesalpiniaceae	Dadmordon	Shrub	Roadside
Senna sophera (L.) Roxb.	Caesalpiniaceae	Kalkesunda	Herb	Roadside
Senna tora (L.) Roxb.	Caesalpiniaceae	Chakunda	Herb	Roadside
Perrisetum glaucum (L.) R. Br.	Poaceae	Bajra	Herb	Cultivated land
Sida acuta Burm. f.	Malvaceae	Nakphul	Herb	Cultivated land
Sida cordata (Burm. f.) Borss.Wallk.	Malvaceae	Junka	Herb	Roadside
Smilax ovalifolia Roxb. *ex* D. Don.	Smilaceaae	Kumarilata	Climber	
Siplanthes acmella (L.) Murray not (L.) L.	Asteraceae	Spilanthes	Herb	Cultivated land
Solanum melongena L.	Solanaceae	Begun	Herb	Homestead
Solanum americanum Mill.	Solanaceae	Puti begun	Herb	Plantation areas

Scientific name	Family	Local name	Habit	Habitat
Solanum torvum Sw.	Solanaceae	Gota begun	Shrub	Plantation areas
Sonneratia apetala Buch.-Ham.	Sonneratiaceae	Keora	Tree	Mangrove areas
Sonneratia caseolaris (L.) Engl.	Sonneratiaceae	Soila	Tree	Mangrove areas
Spondias pinnata (L.f.) Kurz.	Anacardiaceae	Amra	Tree	Homestead
Sterculia foetida L.	Sterculiaceae	Jongli badam	Tree	Plantation areas
Sterculia villosa Roxb.	Stercaliaceae	Bsaket badam	Tree	Plantation areas
Steudnera colocasioides Hook. f.	Araceae	Bishkachu	Herb	Homestead
Streblus asper Lour.	Moraceae	Sheora	Tree	Plantation areas
Swietenia mahagoni (L.) Jacq.	Meliaceae	Mehogoni	Tree	Plantation areas
Syzygium cumini (L.) Skeels	Myrtaceae	Kalo Jam	Tree	Homestead
Tabernaemontana corymbosa Roxb. ex Wall.	Apocynaceae	Tagar	Shrub	Plantation areas
Tabernaemontana divericata (L.) R.Br.*ex* Roem & Schult.	Apocynaceae	Tagar	Shrub	Plantation areas
Tamarindus indica L.	Caesalpiniaceae	Tetul	Tree	Homestead
Tamarix gallica L.	Amaricaceae	Nonajau	Shrub	Mangrove areas
Tectona grandis L.f.	Verbenaceae	Segun	Tree	Plantation areas
Terminalia arjuna (Roxb. *ex* DC.) Wight & Arn	Combretaceae	Arjun	Tree	Plantation areas
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	Bohera	Tree	Plantation areas
Terminalia catappa L.	Combretaceae	Kat badam	Tree	Plantation areas
Terminalia chebula Retz.	Combretaceae	Haritoki	Tree	Plantation areas
Thunbergia latifolia Roxb.	Acanthaceae		Climber	Plantation areas
Thysanolaena maxima (Roxb. *ex* Hornem.) Honda.	Poaceae	Phuljharu	Herb	Cultivated land
Trewia nudiflora L.	Euphorbiaceeae	Pitali	Tree	Plantation areas
Triumfetta rhomboidea Jacq.	Tiliaceae	Banokra	Herb	Plantation areas
Tridax procumbens L.	Asteraceae	Tridhara	Herb	Cultivated land
Typha elephantina Roxb.	Typhaceae	Hogla	Herb	Cultivated land
Woodfordia fruticosa (L.) Kurz	Lythraceae	Dhatri-phul	Shrub	Plantation areas

Scientific name	Family	Local name	Habit	Habitat
Xanthium stromarium L.	Asteraceae	Ghagra	Herb	Roadside
Urena lobata L.	Malvaceae	Banokra	Herb	Roadside
Zingiber montanum (J. Koenig.) Link *ex* A. Dietr.	Zingiberaceae	Paletara	Herb	Plantation areas
Zingiber roseum (Roxb.) Rosc.	Zingiberaceae	Laltara	Herb	Plantation areas
Ziziphus glabrata Heyne ex Roth	Rhamnaceae	Jangli kul	Shrub	Plantation areas
Ziziphus jujuba Mill.	Rhamnaceae	Boroi	Tree	Homestead

such as *Tamarix gallica,Pongamia pinnata, Barringtonia acutangula, Trewia nudiflora,Heritiera fomes, Nypa fruticans, Tamarindus indica, S. apetala, A. officinalis, S. caseolaris, Samanea saman, Albizia procera, Calophylum innophylum, Acacia nilotica, A. farnesiana,Casuarina equisetifolia* and *Rhizophora mucronata.*

One embankment was made on the north site of the National Park to protect Kuakata municipal area from high tidal surges. Besides, many small roads and trails made by encroachers and forest department, and some plantation areas also established inside National Park. Embankment, plantation areas, small roads and trails were planted by the forest department using a number of both native and exotic species. The remarkable species are *Samanea saman, Borassus flabelifer, Phoenix sylvestreis, Casuarina equisetifolia, Acacia nilotica A. farnesiana, A. auriculiformis, A. mangium, Eucalyptus camaldulensis, Albizia lebbeck, Artocarpus heterophyllus, Calophylum innophylum, Nerium indicum, Bauhinia purpurea, Delonix regia, Pongamia pinnata, Dalbergia sissoo, Ficus benghalensis, F. racemosa, Gmelina arborea, Terminalia arjuna, T. bellirica, T. chebula, Butea monosperma, Erythrina indica, Michelia champaca ,Swietenia mahagoni, Excoecaria agallocha, Cassia siamea* and *C. fistula.* Some bushy plants were also found in this sides. The major species are *Ricinus communis, Cajanus cajans, Cassia alata, Calotropis procera, Glycosmis pentaphylla, Clerodendrum viscosum, Datura metel, Hyptis suaveolens, Xanthium indicum, Solanum torvum, Ixora acuminate, Murraya koenigii* and *Ziziphus glabrata.* Many climber species were also ornamented this sides. Most common species are *Mikania cordata, Thunbergia fragrans, Pothos scandens, Hemidesmus indicus, Coccinia grandis, Dioscorea pentaphylla, Hodgsonia macrocarpa, Mucuna pruriens, Ficus pumila, Hedyotis scandens* and *Cuscuta reflexa.*

In the Kuakata National Park, 383 encroachers have occupied of forest land and made homes. Each homestead was planted by a good number of tree species. The appearance of such homestead looks like a segment of mini forest. During our survey *Moringa oleifera, Acacia nilotica, Aegle marmelose, Albizia lebbeck,Albizia procera, Samanea saman, Anacardium occidentale, Annona reticulate, Borassus flabellifer, Anthocephalus cadamba, Aphanamixis polystachya, Areca catechu, Artocarpus chaplasha, Artocarpus heterophyllus, Averrhoa carambola, Azadirachta indica, Bambusa tulda, Citrus maxima,*

Cocos nucifera, Elaeocarpus robustus, Ficus racemosa,Phoenix sylvestreis, Ziziphus mauritiana, Trewia nudiflora, Terminalia chebula, T. bellirica,Tamarindus indica, Syzygium cumini, Swietenia mahagoni, Spondias pinnata, Psidium guajava, Melia azederach, Mangifera indica, Lawsonia inermis, Erythrina indica and *Diospyros malabarica* were recorded.

Aside from plantation areas and homesteads, some areas are used as cultivated land. Local people and encroachers use such land ones in a year for rain fed aman rice cultivation. The most common plants recorded were *Enhydra fluctuans, Eclipta alba, Centella asiatica, Blumea lacera, Tridax procumbe, Heliotropium indicum, Ludwigia repens, Oxalis corniculata, Echinochloa colonum, Oryza sativa, Panicum notatum, Setaria glauca* and *Bacopa monnieri* and also a good number of sedges and grasses. In summer the land was sheltered by a number of herbaceous plants. Among them the common species were *Xanthium indicum, Thysanolaena maxima, Ischaemum indicum, Echinochloa colonum, Sida acuta,Euphorbia hirta, Kyllinga nemoralis, Fimbristylis dichotoma, Cyperus cyperoides, Commelina benghalensis, Blumea membranacea* and *Paspalum distichum.* A rare occurrence of *Typha elephantina* (Hogla) and *Phragmitis karka* (Nol) was also recorded in the wetland.

The four species namely *Tamarix gallica, Calophylum inophylum, Typha elephantina* and *Phragmitis karka* were found to be rare in the National Park. To authenticate their status further comprehensive survey is needed. A good number of medicinal plants were identified which plays important role for the primary healthcare of local people in and around the National Park. Priority should be given for their conservation. The recorded common species in the National Park were *Adhatoda zeylanica, Andrographis paniculata, Achyranthes aspera, Phyllanthus emblica, Ocimum sanctum, Ricinus communis, Azadirachta indica, Aegle marmelos, Alstonia scholaris, Holarrhena antidysenterica, Sonneratia apetala, S. caseolaris, Nypa fruticans, Centella asiatica, Mangifera indica, Scoparia dulcis, Mikania cordata, Ipomoea fistolusa, Terminalia arjuna, T. chebula, T. belliricha, Cassia alata, Diilenia indica, Cynodon dactylon, Colocasia esculenta* and *Ficus racemosa*.

Exotics and invasive species are a component of total floristic composition of the National Park. Some exotics, such as *Acacia auriculiformis, A. mangium, Eucalyptus camaldulensis* and *Cassia siamea* were planted in the National Park area. Invasive species of the National Park were found to be *Eichhornia crassipes, Mikania cordata* (Refugeelota), *Ipomoea fistulosa, Ageratum conyzoides, Croton bonplandianum* and *Xanthium indicum.* Such species are a challenge to the management of the plant diversity of the National Park. A good number of wildlife supporting plant species namely *Sonneratia apetala, S. caseolaris, Avicenneia alba, Ficus benghalensis, F. racemosa, F. virens, Phoenix sylvestreis, Syzygium cummuni, Butea monosperma, Artocarpus chaplasha* and *Tamarindus indica* was recorded from the National Park. Such species play an important role in conservation of biodiversity.

Based on observations and discussion with local people and foresters it is evident that erosion is major threat to the National Park. The south and west sides of the National Park are facing high erosion due to regular sea wave actions. The species planted there are *Acacia nilotica* (Babla), *A. farnesiana* (Khaia Babla), *A. auriculiformis* (Akashmoni), *Pongamia pinnata* (Koroj), *Barringtonia acutangula* (Hizol) and *Trewia nudiflora* (Pitali) all of which are fresh water enduring species. Initially such species were doing better in producing branches and canopy. But their root systems are poorly developed. During high tide period the wave actions made them uprooted easily. Mangrove species like *Sonneratia apetala* (Keora), *S. caseolaris* (Soila), *A. officinalis* (Baen) and *Ex. agallocha* (Gewa) were found to grow well in the intertidal zone because they have strong root systems and can survive with high wave action during rainy season. Facilities and man power of local forest department are not much adequate. Introduction of exotics by forest department is also visible. Grazing by buffalos in the mangrove forest areas, plantation areas and newly accreted lands were also observed.

With the purpose of management of the National Park local knowledge based policy is very essential. During the field trips we discussed with local forest personals, local elites and general people to find some clues for formulating recommendations. The suggestions which are made based on our visit experiences are: to undertake short term and long term management plans, to install geo-tube or geo-bag on the south and west sites for protecting forest degradation and soil erosion, to develop eco-tourism, to ensure security for tourist, to provide visitor use for educational, cultural and recreational purposes at a level which will not cause significant biological or ecological degradation to the biodiversity, to create the sources of fresh water both for human and wildlife, to establish watch towers to enjoy sun rises, sun sets and natural views, to record local knowledge from the elders about nature and adaptation and to record health care knowledge of local people, to create awareness programs about environment, biodiversity and wildlife, to accelerate plantation programs using local species, to provide risk allowance for the people who involved in forest management process, to increase capacity of forest and forest personals, to detect and remove invasive species, to avoid exotics in plantation programs, to arrange traditional knowledge based cultural program, to create traditional medicinal knowledge sharing programs, to relocate encroachers from the park, finally to ensure land ownership and forest territory using GIS map.

The present work on the assessment of angiosperm diversity in Kuakata National Park is the first attempt. The record of total 265 angiosperm species in the park is very preliminary. We expected more angiosperm species yet to be identified. It is not possible to give a concrete conclusion based on such preliminary results. Long term floristic survey is necessary to cover all the component of the angiosperms and also other group of plants.

Acknowledgements

Bangladesh Forest Department and local forest offices of Patuakhali Coastal Forest Division and Kuakata National Park are greatly acknowledged for financial support and facilities. The authors are also grateful to the Wildlife Center of Bangladesh Forest Department for implementing research work.

References

Ahmed, Z.U., Z.N.T. Begum, M. A. Hassan, M. Khondker, S. M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque (Eds). 2008a. *Encyclopedia of Flora and Fauna of Bangladesh,* Vol. **6**. Angiosperms: Dicotyledons (Acanthaceae – Asteraceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-408.

Ahmed, Z.U., M.A. Hassan, Z.N.T. Begum, M. Khondker, S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque (Eds). 2008b. *Encyclopedia of Flora and Fauna of Bangladesh,* Vol. **12**. Angiosperms: Monocotyledons (Orchidaceae – Zingiberaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-552.

Ahmed, Z.U., M.A. Hassan, Z.N.T. Begum, M. Khondker, S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque (Eds). 2009b. *Encyclopedia of Flora and Fauna of Bangladesh*, Vol.**7.** Angiosperms: Dicotyledons (Balsaminaceae – Euphorbiaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-546.

Ahmed, Z.U., M.A. Hassan, Z.N.T. Begum, M. Khondker, S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque (Eds). 2009c. *Encyclopedia of Flora and Fauna of Bangladesh*, Vol.**8**. Angiosperms: Dicotyledons (Fabaceae –Lythraceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-478.

Ahmed, Z.U., M.A. Hassan, Z.N.T. Begum, M. Khondker, S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque (Eds). 2009d. *Encyclopedia of Flora and Fauna of Bangladesh,*Vol. **9**. Angiosperms: Dicotyledons (Magnoliaceae – Punicaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-488.

Ahmed, Z.U., M.A. Hassan, Z.N.T. Begum, M. Khondker, S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque (Eds).2009e. *Encyclopedia of Flora and Fauna of Bangladesh,* Vol. **10**. Angiosperms: Dicotyledons (Ranunculaceae – Zygophyllaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-580.

Ahmed, Z.U., M. Khondker, Z.N.T. Begum, M.A. Hassan, S.M.H. Kabir,M. Ahmad, A.T.A. Ahmed and A.K.A. Rahman (Eds). 2009a. *Encyclopedia of Flora and Fauna of Bangladesh,* Vol. **4**. Algae: Charophyta-Rhodophyta (Achnanthaceae– Vaucheriaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-543.

Akter, A. and M.I. Zuberi. 2009. Invasive alien species in northern Bangladesh: Identification, inventory and impacts. *International journal of biodiversity and conservation.***1(5)**: 129-134.

Alexiades, M.N. (Ed.).1996. *Selected Guidelines for Ethno botanical Research: A Field Manual.* The New York Botanical Garden, New York.

Ara, H., B. Khan and S.N. Uddin (Eds.). 2013. *Red data book of vascular plants of Bangladesh,* Vol.**2**. Bangladesh National Herbarium, Dhaka, Bangladesh. p.280.

Balick, M.J., A. B. Anderson and M. F.da Silva.1982. Plant taxonomy in Brazilian Amazonia: The state of systematic collection in regional herbaria. Brittonia **14**: 463-477.

BFD, (Bangladesh Forest Department) 2006. Master plan of Kuakata Eco-Park. Bangladesh Forest Department, Agargaon, Dhaka, Bangladesh. pp.5-6.

BFD, (Bangladesh Forest Department) 2012. State of Bangladesh's forest protected areas. IPAC and Bangladesh Forest Department, Agargaon, Dhaka, Bangladesh. 63.

Cronquist, A. 1981. *An integrated system of classification of flowering plants.* Columbia University Press, New York, p. 1262.

Goldsmith, F.B. and C.M. Harrison.1976.Description and analysis of vegetation .*In*: Champman SB (ed.). *Methods in plant ecology.* Blackwell, Oxford, pp. 85-155.

Hossain, M.K. and M.K. Pasha. 2004. An account of the exotic flora of Bangladesh. *Journal of forestry and environment.* **2**: 99-115.

Hyland, B.P.M. 1972. A technique for collecting botanical specimens in rain forest. Flora Malesiana Bulletin. **26**: 2038-2040.

Khan, M.S. and A. M.Huq. 2001. The vascular flora of Chunati Wildlife Sanctuary in south Chittagong, Bangladesh. *Bangladesh J. Plant. Taxon*. **8**(1): 47-64.

Khan, M.S., M.M. Rahman and M.M. Ali (eds.). 2001. *Red Data Book of Vascular Plants of Bangladesh*. Bangladesh National Herbarium. 179.

Khan, M.S., M.M. Rahman, A.M. Huq, M.M.K Mia and M.A.Hassan.1994. Assessment of biodiversity of Teknaf game reserve in Bangladesh focusing on economically and ecologically important plants species. *Bangladesh J. Plant.Taxon.***1**(1): 21-33.

Rahman, M.O. and M.A. Hassan.1995.Angiospermic flora of Bhawal Narional Park, Gazipur, Bangladesh. *Bangladesh J. Plant Taxon.* **2**(1&2): 47-79.

Sajib, N.H., S.B. Uddin and M.K. Pasha. 2015. Angiospermic Plant Diversity of Sandwip Island, Chittagong, Bangladesh. *J. Asiat. Soc. Bangladesh, Sci*. **41**(2): 133-153.

Siddiqui, K.U., M.A.Islam, Z.U.Ahmed, Z.N.T Begum, M.A. Hassan, M. Khondker, M. M. Rahman, S.M.H Kabir, M. Ahmad, A.T.A Ahmed, A.K.A Rahman and E.U. Haque (Eds).2007. *Encyclopedia of Flora and Fauna of Bangladesh*. Vol.**11**. Angiosperms: Monocotyledons (Agavaceae -Najadaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-399.

Uddin, M.Z., M. F.Alam, A.S.M. Rahman and M.A. Hassan. 2011. Plant Biodiversity of Fashiakhali Wildlife Santuary, Bangladesh. Accepted for publication in First Bangladesh Forestry Congress Proceeding 2011. pp.129-141.

Uddin, S.B. and M.A. Rahman.1999. Angiospermic flora of Himchari National Park, Cox's Bazar, *Bangladesh. J. Plant Taxon*. **6**(1): 31-68.

Uddin, M.Z. and M.A. Hassan.2010. Angiosperm diversity of Lawachara National Park (Bangladesh): a preliminary assessment. *Bangladesh J. Plant Taxon*. **17** (1): 9-22.

Uddin, M.Z. and M.A. Hassan. 2004. *Flora of Rema-Kalenga Wildlife Sanctuary*. IUCN Bangladesh Country Office, Dhaka, Bangladesh, pp.1-120.

Uddin, M.Z., M.F. Alam, M.A. Rahman and M.A. Hassan. 2013. Diversity in angiosperm flora of Teknaf Wildlife Sanctuary, Bangladesh. *Bangladesh J. Plant Taxon*. **20**(2): 145-162.

Uddin, S.N., M.S. Khan, M.A. Hassan and M.K. Alam.1998. An annotated checklist of angiospermic flora of Sitapahar at Kaptai in Bangladesh. *Bangladesh J. Plant Taxon.* **5**(1): 13-46.

Uddin, M.Z., M.G. Kibria and M.A. Hassan. 2015. An assessment of angiosperm plant diversity of Nijhum Dweep (Island). *J. Asiat. Soc. Bangladesh,Sci.***41**(1): 19-32.

Uddin, M.Z. and M. Abiabdullah. 2016. Taxonomic study on the angiosperms of Char Kukri Mukri Wildlife Sanctuary. *J. Asiat. Soc. Bangladesh,Sci*.**42**(2): 153-168.

(Revised copy received on 10-12-2017)

J. Asiat. Soc. Bangladesh, Sci. 43(2): 161-172, December 2017

TAXONOMIC ENUMERATION OF ANGIOSPERM FLORA OF SREENAGAR UPAZILA, MUNSHIGANG, DHAKA, BANGLADESH

ZAKIA MAHMUDAH, MD. MUZAHIDUL ISLAM,
TAHMINA HAQUE AND MOHAMMAD ZASHIM UDDIN[1]
Department of Botany, University of Dhaka, Dhaka-1000, Bangladesh

Abstract

The present article focuses the status of angiosperm flora of Sreenagar *upazila* under Munshiganj district. The study was done from July 2015 to June 2016. A total of 219 plant species of angiosperms was identified belonging to 165 genera and 70 families. Among them 38 species were monocotyledons and 181 plant species were dicotyledons. Herbs were the largest life forms among the angiosperms and contained about 58% of total plant species occurring in this area. Trees and shrubs occupied 23% and 12% respectively. Climbers were 6% but epiphytes (1%) were very negligible in number in the study area. About 51 medicinal plants were recorded from this study. The following species viz. *Lasia spinosa*, *Calamus tenuis*, *Tinospora crispa*, *Passiflora foetida* and *Calotropis procera* were recorded only once and hence considered as rare species in Sreenagar *upazila*. An invasive poisonous plant *Parthenium hysterophorus* was also found in Sreenagar.

Key words: Diversity, Angiosperm flora, Sreenagar, Munshiganj district

Introduction

Sreenagar is an *upazila* under Munshiganj district situated on the bank of 'Padma' river. It is a part of Dhaka division, located in between 23°27' and 23°38' north latitudes and in between 90°10' and 90°22' east longitudes. The total area is 202, 98 square kilometer and bounded by Serajdikhan and Nawabganj *upazilas* on the north, Lohajong and Shibchar upazilas on the south, Serajdikhan and Nawabganj and Dohar *upazilas* on the west. It consists of 14 union parishads, 102 mouzas and 148 villages. The temperature of this area fluctuates between 13.7 ^{o}C and 37.7 ^{o}C throughout the year. Monthly average relative humidity varies from 54 to 82% throughout the year. The highest precipitation was found in July. Sreenagar *upazila* presents diverse types of habitats, e.g. char lands, riparian, homestead, roadside, wetland (Sarker 2012).

Angiosperm flora of Sreenagar *upazila* has great economic and cultural importance especially in providing food, medicine, fuel and shelter for the local people. It also plays a key role in maintaining the environmental balance and ecosystem stability of the area. Plants of this area have been facing many threats. These are habitat loss and fragmentation, introduction of exotic species, loss of pollinators, over exploitation, pollution and developmental work for (e.g. Padma bridge construction). A good number

[1] Corresponding author: zashim01@gmail.com

of floristic studies on the angiosperm flora of different areas of Bangladesh had already been published. (Khan *et al.* 1994, Rahman and Hassan 1995, Uddin *et al.* 1998, Khan and Huq 2001, Uddin *et al.* 2011, Uddin and Hassan *et al.* 2004, 2010; Uddin *et al.* 2013 and Rahman *et al.* 2013). But there was no study on the angiosperm flora of Sreenagar *Upazila*. Thus this study was conducted to know the present status of angiosperm flora of Sreenagar *Upazila* and to find out the threats and stress for the plant community of this area.

Materials and Methods

Plant samples were collected from the study area in different seasons during July 2015 to June 2016 through six repeated field trips. The area was divided into 14 spots (Sreenagar *upazila*, Atpara, Tantar, Kukutia, Sholaghar, Rarikhal, Hasara, Kolapara, Shamsiddhi, Bhagyakul, Bhagra, Birtarafor, Baraikhali, Patabhog) for collecting plant samples. The survey covered all habitats and ecosystems of the study site including homestead, road sides, char lands, aquatic bodies and cultivated lands. Voucher specimens processed using standard herbarium techniques (Hyland 1972). The specimens were identified consulting different Floras viz., Hooker 1872-1897, Prain 1903, Uddin and Hassan 2004, Siddiqui *et al.* (2007c) and Ahmed *et al.* (2008a, 2008b, 2009b, 2009c, 2009d, 2009e). Specimens available at Dhaka University Salar Khan Herbarium (DUSH) were consulted in identifying the collected plant specimens. The updated nomenclature of the species followed Siddiqui *et al.* (2007c) and Ahmed *et al.* (2008a, 2008b, 2009b, 2009c, 2009d, and 2009e). Voucher specimens are deposited at DUSH. The species representation in the families varied from 1 to 16. In both monocot and dicot angiosperms, Poaceae is the largest family represented by 16 species and Asteraceae and Moraceae is the second largest family represented by 11 species Fig.1 showing the top dominated families. Poaceae, Asteraceae were also reported to be the largest family in a previous study from Bangladesh (Uddin and abiabdullah 2016 and Rahman *et al.* 2013).

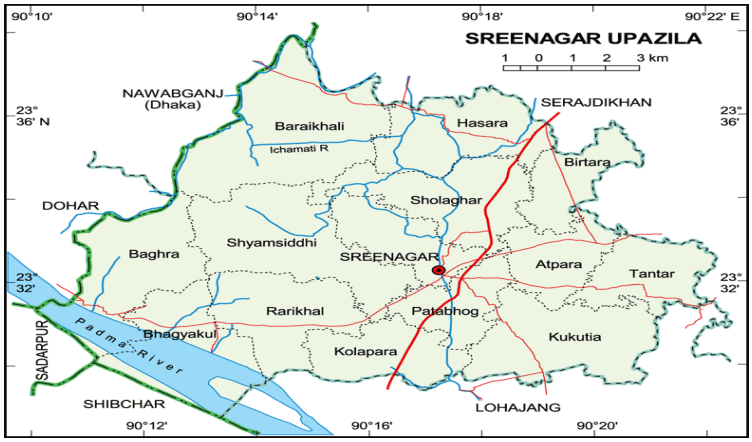

Fig. 1. Map of Sreenagar *Upazila*.

Results and Discussion

A total of 219 angiosperm species was identified under 165 genera and 70 families. Among them Magnoliopsida (dicotyledons) is represented by 181 Species belonging to 129 genera and 58 families, whereas Liliopsida (monocotyledons) by 38 species under 36 genera and 12 families only. For each species local name, scientific name, family, habit and habitat are presented in Table 1. Among the species, 126 are represented by herbs, 26 by shrubs, 54 by trees and 12 by climbers and epiphyte (Fig. 3). Poaceae having 16 species is the largest family in monocotyledon whereas Asteraceae and Moraceae both having 11 species in each family in dicotyledon. Local people use different plants for medicinal purposes. 51 medicinal plants were found from this study. It is about 23% of the total flora. Roadside vegetation occupied the highest number of identified plant species and was 36% of total species.

Table1. Plant diversity of Sreenagar *upazila*.

Scientific Name	Local Name	Family Name	Habit	Habitat	Coll. No.
Abelmoschus esculentus (L.) Moench	Dherosh	Malvaceae	H	Cultivated	120
Acacia auriculiformis A. Cunn. ex Benth. & Hook.	Akashmoni	Mimosaceae	T	Road side	52
Acacia nilotica L.	Babla	Fabaceae	T	Road side	62
Acalypha indica L.	Muktajhuri	Euphorbiaceae	S	Road side	268
Achyranthes aspera L.	Bilaiachra	Amaranthaceae	H	Road side	22
Adenosma indianum (Lour.) Merr.	Barakesuti	Scrophulariaceae	H	Char	76
Adenostemma lavenia (L.) O. Kuntze	Borokesuti	Asteraceae	H	Road side	176
Aegle marmelos (L.) Corr.	Bel	Rutaceae	T	Homestead	222
Ageratum conyzoides L.	Fulkuri	Asteraceae	H	Road side	7
Albizia lebeck (L.) Benth.	Siris	Fabaceae	S	Road side	20
Allium cepa L.	Piaj	Amaryllidaceae	H	Cultivated	39
Allium sativum L.	Rosun	Amaryllidaceae	H	Cultivated	26
Alocasia cucullata (Lour.) G. Don	Bishkachu	Araceae	H	Homestead	174
Aloe vera (L.) Brum. f.	Gritokumari	Aloeaceae	H	Homestead	40
Alstonia scholaris (L.) R. Br.	Chatim	Apocynaceae	T	Road side	180
Alternanthera philoxeroides (Mart.) Griseb.	Helencha	Amaranthaceae	H	Riparian	168
Alternanthera sessilis (L.) R. Br. ex. Roem. & Schult.	Sachi shak	Amaranthaceae	H	Char	1
Amaranthus blitum L.		Amaranthaceae	H	Cultivated	233
Amaranthus spinosus L.	Kanta nutia	Amaranthaceae	S	Cultivated	30
Amaranthus tricolor L.	Lal shak	Amaranthaceae	H	Cultivated	240
Amaranthus viridis L.	Note shak	Amaranthaceae	T	Cultivated	46
Annona reticulata L.	Ataphal	Annonaceae	T	Homestead	83
Annona squamosa L.	Sharifa	Annonaceae	T	Homestead	279
Areca catechu L.	Supari	Arecaceae	T	Homestead	152
Artocarpus heterophyllus Lamk.	Kathal	Moraceae	T	Homestead	192
Artocarpus lakucha Buch.-Ham.	Dewa	Moraceae	T	Homestead	163
Averrhoa carambola L.	Kamranga	Oxalidaceae	H	Homestead	215
Azadirachta indica A. Juss.	Nim	Meliaceae	T	Homestead	64

Contd.

Scientific Name	Local Name	Family Name	Habit	Habitat	Coll. No.
Barringtonia acutangula (L.) Gaertn.	Hijol	Lecythidaceae	H	Riparian	290
Basella alba L.	Puishak	Basellaceae	H	Homestead	213
Bauhinia variegata L.	Lal kanchon	Caesalpiniaceae	T	Homestead	242
Blumea lacera (Burm. f.) DC.	Shialmdra	Asteraceae	H	Road side	266
Boehmeria nivea (L.)Gaudich.	-	Utricaceae	H	Road side	87
Bombax ceiba L.	Shimul	Bombacaceae	H	Road side	49
Borassus flabellifer L.	Tal	Arecaceae	T	Road side	50
Bougainvillea glabra Choisy.	Baganbilas	Nyctaginaceae	H	Homestead	288
Cajanus cajan(L.) Millsp.	Arhor dal	Fabaceae	T	Road side	194
Calamus tenuis Roxb.	Bet	Arecaceae	T	Riparian	73
Calotropis gigantea (L.) R. Br.	Akondo	Asclepiadaceae	S	Road side	200
Capsicum frutescens L.	Morich	Solanaceae	H	Cultivated	185
Cardiospermum helicacabum L.	Vat	Sapindaceae	H	Road side	61
Carica papaya L.	Pepe	Caricaceae	T	Homestead	220
Carissa carandas L.	Koromcha	Apocynaceae	T	Homestead	283
Caryota urens L.	Fish tail palm	Arecaceae	H	Road side	287
Cassia javanica L.	Java sonalu	Caesalpiniaceae	T	Road side	179
Cassia nodosa Buch.-Ham. ex Roxb.	Bansonalu	Caesalpiniaceae	H	Road side	60
Casuarina equisetifolia Forst.	Jhaw	Casuarinaceae	H	Char	286
Catharanthus roseus (L.) G. Don	Noyon tara	Apocynaceae	H	Homestead	70
Cayratia trifolia (L.) Domin.	Gowalialata	Vitaceae	C	Road side	265
Celosia argentea L.	Morog ful	Amaranthaceae	H	Homestead	71
Centella asiatica (L.) Urban.	Thankune	Apiaceae	H	Homestead	165
Cestrum nocturnum L.	Hasna hena	Solanaceae	S	Homestead	246
Chamaecrista mimosoides (L.) Greene.	-	Caesalpiniaceae	H		21
Chenopodium album L.	Bothua shak	Chenopodiaceae	T	Char	295
Chloris gayana Kunth.	-	Poaceae	C		10
Chromolaena odorata (L.) King & Robinson.	Assamlata	Asteraceae	H	Road side	19
Chylocalyx perfoliatus (L.) Hassk.ex Miq.	Kantatok pata	Polygonaceae	H	Char	53
Citrus limon (L.) Burm.	Lebu	Rutaceae	S	Homestead	45
Citrus maxima (Burm.) Merr.	Batabi lebu,Jambura	Rutaceae	S	Homestead	150
Cleome gynandra L.	Hurhuria	Capparaceae	H	Road side	136
Cleome rutidosperma DC.	-	Capparaceae	T	Riparian	32
Coccinia grandis (L.) Voigt.	Telakucha	Cucurbitaceae	C	Road side	43
Cocos nucifera L.	Narikel	Arecaceae	T	Homestead	88
Codiaeum variegatum (L.) A. Juss.	-	Euphorbiaceae	H	Homestead	172
Coix lacryma-jobi L.	Kunch,Tasbi	Poaceae	H	Rice field	128
Commelina benghalensis L.	Kanailota	Commelinaceae	H	Road side	82
Conyza aegyptiaca (L.) W. Ait.	-	Asteraceae	H	Road side	11
Corchorus capsularis	Deshi pat	Tiliaceae	H	Cultivated	97
Crateva magna (Lour.) DC.	Bannya,barun	Capparaceae	T	Riparian	297

Contd.

Scientific Name	Local Name	Family Name	Habit	Habitat	Coll. No.
Croton bonplandianus Baill.	Bondhone	Euphorbiaceae	H	Road side	8
Cucumis sativus L.	Shasa,Khira	Cucurbitaceae	C	Cultivated	126
Cucurbita maxima Duch.ex Lamk.	Mistialu	Cucurbitaceae	C	Cultivated	65
Cucurbita moschata Duch. Ex Poir.	Safra kumra	Cucurbitaceae	H	Cultivated	143
Cuscuta reflexa Roxb.	Swarnalata	Cuscutaceae	Epiphyte	Epiphyte, Roadside	284
Cyclea barbata Miers.	Patalpur	Menispermaceae	H	Road side	5
Cynodon dactylon *L.*	Durba	Poaceae	H	open field	79
Cyperus iria L.	-	Cyperaceae	H	Cultivated land	167
Cyperus rotundus	Mutha gash	Cyperaceae	H	Cultivated land	13
Dactyloctenium aegyptium(L.) P.Beauv.	Makra	Poaceae	H	Road side	80
Dalbergia sisso Roxb.	Shisu	Fabaceae	S	Road side	48
Datura metel L.	Dhutra	Solanaceae	H	Road side	267
Dendrocalamus strictus Roxb. Nees.	Karail	Poaceae	H	Rice field	89
Digitaria bicornis (Lamk.) Roem. & Schult. ex Loud.	-	Poaceae	H	Road side	14
Digitaria stricta Roth ex Roem. & Schult.	Ghash	Poaceae	H	Road side	18
Digitaria ternata (A. Rich.) Stapf ex Dyer.	Ghash	Poaceae	H	Road side	91
Dillenia indica L.	Chalta	Dilleniaceae	T	Homestead	93
Dioscorea alata L.	Chupri alu	Dioscoriaceae	T	Homestead	92
Diospyros discolor Willd.nom illeg.Verheij & Coronel.	Bilatigab	Ebenaceae	T	Homestead	119
Diospyros malabarica (Desr. Kostel.	-	Ebenaceae	T	Homestead	42
Duranta repens L.	Duranta	Verbenaceae	H	Homestead	271
Echinochloa colonum (L.) Link.	Buno Dhan	Poaceae	H	Road side	158
Eichhornia crassipes (Mart.) Solms.	Kochuripana	Pontederiaceae	H	Aquatic	161
Elaeocarpus tectorius (Lour.) Poir.	Jolpai	Elaeocarpaceae	H	Homestead	182
Eucalyptus camaldulensis Dehnhardt.	Eucalyptus	Myrtaceae	T	Road side	107
Euphorbia hirta L.	Dudhia	Euphorbiaceae	H	Road side	37
Euphorbia thymifolia L.	Dudhiya	Euphorbiaceae	H	Road side	260
Ficus benghalensis L.	Bot	Moraceae	T	Road side	124
Ficus heterophylla	Bot	Moraceae	T	Road side	162
Ficus hispida L. f.	Kak dumur	Moraceae	T	Road side	177
Ficus racemosa L.	Dumur	Moraceae	T	Road side	35
Ficus religiosa L.	Ashok	Moraceae	T	Road side	101
Ficus rumphii Blume.	Gaiaswathwa	Moraceae	T	Road side	59
Fioria vitifolia (L.) Mattei.	-	Malvaceae	H	Road side	110
Glinus oppositifolius (L.) A. DC.	Gimashak	Molluginaceae	H	Char	296
Glycosmis pentaphylla (Retz.) A. DC.	Matkila,Datmajoni	Rutaceae	S	Road side	131
Heliotropium indicum L.	Hatishur	Boraginaceae	H	Cultivated	78
Hibiscus fragrans Roxb.	Joba	Malvaceae	S	Homestead	99
Hibiscus rosa-sinensis L.	Joba	Malvaceae	S	Homestead	285
Hibiscus schizopetalus (Mast.) Hook. f.	Jhumko Joba	Malvaceae	S	Homestead	291

Contd.

Scientific Name	Local Name	Family Name	Habit	Habitat	Coll. No.
Hibiscus surattensis L.	Joba	Malvaceae	S	Road side	210
Hydrocotyle sibthorpioides Lamk.	Unknown	Apiaceae	H	Aquatic	121
Hygrophila schulli (Buch.-Ham.) M. R. & S. N. Almeida.	Talmakhna	Acanthaceae	H	Aquatic	171
Indigofera tinctoria L.	Nil	Fabaceae	S	Cultivated	90
Ipomea indica (Burm.f.) Merr.	Kolmi	Convolvulaceae	H	Aquatic	135
Ipomoea aquatica Forssk.	Kolmi	Convolvulaceae	H	Aquatic	145
Ipomoea batatas (L.) Lamk.	Mistialu	Convolvulaceae	H	Cultivated	303
Ipomoea fistulosa Mart. ex Choisy.	-	Convolvulaceae	H	Aquatic	311
Ixora coccineaL.	Rongon	Rubiaceae	S	Homestead	300
Justicia gendarussa Burm. f.	Jogotmordon	Acanthaceae	H	Homestead	103
Kyllinga brevifolia Rottb.	-	Cyperaceae	T	Road side	146
Lagenaria siceraria (Molina) Standl.	Lau	Cucurbitaceae	C	Cultivated	209
Lasia spinosa (L.) Thw.	Kanta kachu	Araceae	H	Riparian	151
Lawsonia inermis L.	Mehedi	Lythraceae	S	Homestead	140
Lepidagathis incurva Buch-Ham. ex D. Don.	-	Acanthaceae	H	Homestead	142
Leucas cephalotes (Roth.) Spreng.	Bara halkus	Lamiaceae	H	Homestead	276
Limonia acidissima L.	Kotbel	Rutaceae	T	Homestead	123
Lippia alba (Mill.) Briton et Wilson.	Lippia	Verbenaceae	H	Char	211
Litchi chinensis Sonn.	Lichu	Sapindaceae	T	Homestead	138
Ludwigia adscendens (L.) Hara.	Mulsi	Onagraceae	h	Aquatic	72
Ludwigia hyssopifolia (G. Don) Exell.	-	Onagraceae	H	Aquatic	51
Ludwigia perennis L.	-	Onagraceae	H	Aquatic	313
Malvaviscus arboreus Cav.	Joba	Malvaceae	S	Homestead	195
Mangifera indica L.	Aam	Anacardiaceae	T	Homestead	187
Melia azedarach L.	Goranim	Meliaceae	T	Road side	69
Melocanna baccifera (Roxb.)Kurz.	Muli bash	Poaceae	H	Cultivated	147
Mikania cordata (Burm.f.) Robinson.	Asamlata,Tarulata	Asteraceae	C	Road side	148
Mirabilis jalapa L.	Shondha moni	Nyctaginaceae	S	Homestead	157
Mollugo pentaphylla L.	Khetpapra	Molluginaceae	H	Char	56
Momordica charantia L.	Uchchhe	Cucurbitaceae	C	homestead	235
Monochoria hastata (L.) Solms.	-	Pontederiaceae	H	Aquatic	17
Moringa oliefera Lamk.	Sajina	Moringaceae	T	Homestead	57
Morus macroura Miq.	Tute	Moraceae	T	Road side	183
Murraya paniculata (L.) Jack.	Kamini	Rutaceae	S	Homestead	141
Musa paradisiaca L.	Kola	Musaceae	H	Homestead	203
Mussaenda erythrophylla Schum. & Thonn.	Macchenda	Rubiaceae	S	Homestead	129
Neolamarckia cadamba (Roxb.) Bosser.	Kokom	Rubiaceae	T	Road side	125
Nymphaea nouchali Burm. f.	Nil shapla	Nymphaeaceae	H	Aquatic	149
Nymphaea pubescens Willd	Shapla	Nymphaeaceae	H	Aquatic	160
Ocimum basilicum L.	Babui tulsi	Lamiaceae	S	Homestead	38
Ocimum gratissimum L.	Pantulsi	Lamiaceae	T	Homestead	75
Oryza sativa L.	Dhan	Poaceae	H	cultivated	159
Oxalis corniculata L.	Amrul	Oxalidaceae	T	open field	241

Contd.

Scientific Name	Local Name	Family Name	Habit	Habitat	Coll. No.
Oxalis corymbosa DC.	-	Oxalidaceae	H	Char	47
Panicum milliaceum L.	Cheena chaul	Poaceae	H	Rice field	164
Parthenium hysterophorus	-	Asteraceae	H	Char	166
Paspalum distichum L.	-	Poaceae	H	Cultivated	170
Passiflora foetida L.	Passiflora	Passifloraceae	H	Road side	184
Pedilanthus tithymaloides Poit.	Rangchita	Euphorbiaceae	H	Homestead	199
Peperomia pellucida (L.) H. B. & K.	Luchipata	Piperaceae	H	Road side	95
Persicaria glabra (Willd.)Gomez de la Maza.	Lal kukri	Polygonaceae	H	Riparian	36
Persicaria hydropiper (L.) Spach.	Panimorich	Polygonaceae	H	Char	28
Persicaria lanata (Roxb.) Hassan.	Shet panimorich	Polygonaceae	H	Riparian	29
Persicaria lapathifolia (L.) S. F. Gray.	Panimorich	Polygonaceae	H	Aquatic	231
Phoenix sylvestris Roxb.	Khejur	Arecaceae	T	Road side	186
Phyla nodiflora (L.) Greene.	Bhuiokra	Verbenaceae	H	Road side	308
Phyllanthus emblica L.	Amloki	Phyllanthaceae	H	Cultivated	307
Phyllanthus niruri L.	Bhuiamla	Euphorbiaceae	S	Road side	81
Phyllunthus reticulatus Poir.	Chitki	Phyllanthaceae	T	open field	278
Physalis angulata L.	Fotka	Solanaceae	H	Road side	3
Physalis minima L.	Fotka	Solanaceae	H	Road side	41
Piper sylvaticum Roxb.	Pan	Piperaceae	H	Homestead	44
Pistia stratiotes L.	Topapana	Araceae	H	Aquatic	178
Polyalthia longifolia (Sonn.) Thw.	Debdaru	Annonaceae	T	Road side	86
Porana paniculata Roxb.	-	Convolvulaceae	H	Road side	312
Portulaca grandiflora Hook.	Time ful	Portulacaceae	H	Homestead	181
Portulaca oleracea L.	Nunta shak	Portulacaceae	H	Char	156
Psidium guajava L.	Peara	Myrtaceae	S	Homestead	139
Punica granatum L.	Dalim	Punicaceae	S	Homestead	239
Raphanus sativus L.	Mula	Brassicaceae	H	Homestead	202
Ricinus communis L.	Bherenda	Euphorbiaceae	T	Road side	24
Ruellia tuberosa L.	Chatpoty	Acanthaceae	H	Road side	94
Saccharum officinarum L.	Akh	Poaceae	H	Cultivated land	223
Saccharum spontaneum L.	Kash	Poaceae	H	Riparian	133
Scoparia dulcis L.	Bondhone	Scrophulariaceae	H	Road side	299
Senna hirsuta (L.) Irwin & Barneby.	-	Caesalpiniaceae	H	Road side	106
Senna obtusifolia (L.) Irwin & Barneby.	-	Caesalpiniaceae	H	Road side	304
Senna occidentalis Roxb.	Bora chalkesunda	Caesalpiniaceae	H	Road side	113
Senna tora (L.) Roxb.	Kalkasam	Caesalpiniaceae	T	Homestead	98
Sesamum indicum L.	Til	Pedaliceae	C	Cultivated land	257
Sesbania bispinosa	Dhaincha	Fabaceae	H	Cultivated land	169
Setaria barbata (Lamk.) Kunth.	-	Poaceae	H	Cultivated	9
Sida acuta Burm.	Kureta	Malvaceae	H	Road side	2
Solanum americanum Mill.	Titbegun	Solanaceae	H	Road side	293
Solanum melongena L.	Begun	Solanaceae	H	Cultivated	188

Contd.

Scientific Name	Local Name	Family Name	Habit	Habitat	Coll. No.
Solanum nigrum L.	Titbegun	Solanaceae	H	Road side	114
Solanum tuberosum	Alu	Solanaceae	H	Cultivated	189
Spilanthes calva DC.	Surja kannya	Asteraceae	H	Char	6
Streblus asper Lour.	Sheora	Moraceae	T	Road side	175
Swietenia mahagoni Jacq.	Mehogoni	Meliaceae	T	Homestead	153
Synedrella nodiflora (L.) Gaertn.	-	Asteraceae	H	open field	34
Syzygium cumini (L.) Skeels	Jam	Myrtaceae	T	Homestead	55
*Syzygium samar*angense	Jamrul	Myrtaceae	T	Homestead	207
Tabernaemontana divaricata (L.) R. Br. ex Roem. & Schult.	Togor	Apocynaceae	S	Homestead	298
Tagetes erecta L.	Gadha	Asteraceae	H	homestead	193
Tamarindus indica L.	Tentul	Caesalpiniaceae	H	Road side	132
Tectona grandis L. f.	Segun	Dipterocarpaceae	T	Homestead	54
Terminalia arjuna (Roxb. ex DC.)Wight & Arn.	Arjun	Combretaceae	H	Road side	250
Thevetia peruviana (Pers.) K. Schum.	Halde karabi	Apocynaceae	S	Homestead	281
Tinospora crispa (L.) Hook. f. & Thoms.	Gulancha	Menispermaceae	C	Homestead	196
Trema orientalis (L.) Blume.	-	Cannabaceae	H	Road side	204
Triticum aestivum L.	Gom	Poaceae	H	Cultivated	197
Typhonium trilobatum (L.) Schott.	Ghet kachu	Araceae	H	Homestead	208
Urena lobata L.	Ban okra	Malvaceae	H	Road side	4
Vigna adenantha (Meyer) Marechal et al.	Bonborboti	Fabaceae	C	Cultivated	155
Vigna unguiculata (L.) Walp.	Borboti	Fabaceae	H	Road side	191
Wedelia trilobata (L.) A. S. Hitchc.	-	Asteraceae	H	Road side	31
Xanthium indicum Koen ex Roxb.	Gagra	Asteraceae	C	Road side	27
Zea mays L.	Vutta	Poaceae	H	cultivated	198
Ziziphus oenoplia (L.) Mill.	Boroi	Rhamnaceae	T	Homestead	104

(T= tree, S =shrub, H= herb, C= climber)

In the study area, *Barringtonia acutangula* (Hijol), *Crateva magna*, *Persicaria lanata* (Panimorich), *Saccharum spontaneum* are commonly found in bank of rivers and canals. Paddy (Oryza sativa), potato (*Solanum tuberosum*), wheat (*Triticum aestivum*), sweet pumpkin (*Cucurbita pepo*) and maize (*Zea mays*) are the main cultivated crops which are exposed during dry season. In the rainy season the land is mainly used for cultivation of dhaincha (*Sesbania bispinosa*) and jute (*Corchorus capsularis*).

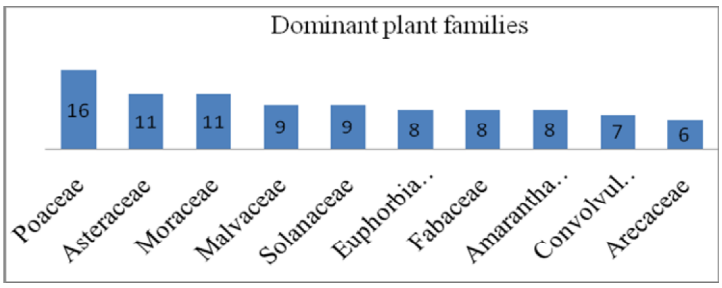

Fig. 2. Top ten dominant families along with the number of species.

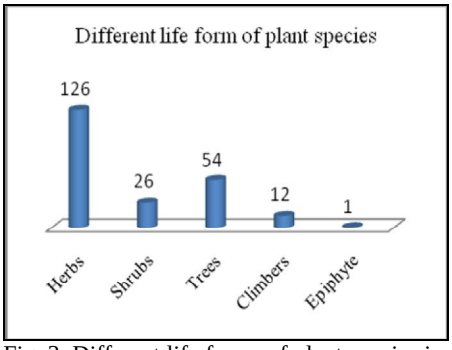

Fig. 3. Different life forms of plant species in Sreenagar Upazila.

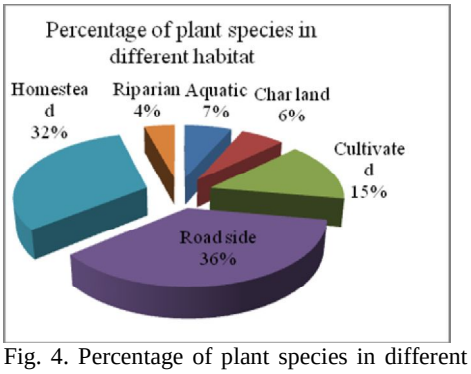

Fig. 4. Percentage of plant species in different habitats in Sreenagar upazila.

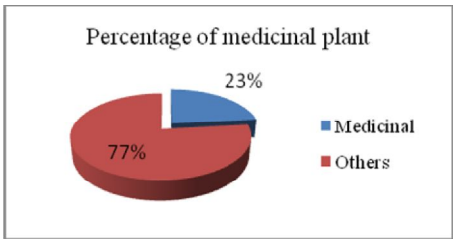

Fig. 5. Percentage of medicinal and non medicinal plant species.

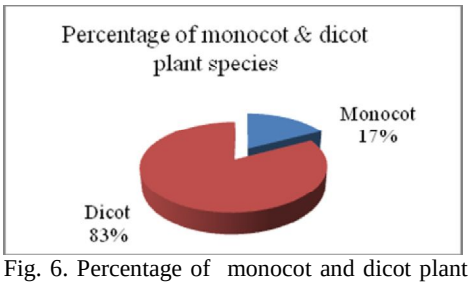

Fig. 6. Percentage of monocot and dicot plant species

The remarkable wild species of the study area are *Persicaria lanata, Lippia alba, Streblus asper, Synedrella nodiflora, Trema orientalis, Typhonium trilobatum, Xanthium indicum etc. Alternanthera sessilis, Chenopodium album, Glinus oppositifolius, Phyla nodiflora, Portulaca oleracea, Synedrella nodiflora, Oxalis corniculata* are commonly found to form the vegetation in char land. Some common aquatic angiosperms are *Eichhornia crassipes, Enhydra fluctuans, Ipomoea aquatica, Ludwigia adscendens, Ludwigia hyssopifolia, Nymphaea nouchali* and *Pistia stratiotes.*

Crateva magna (Bannya,barun), Barringtonia acutangula (Hijol), Alstonia scholaris, Azadirachta indica, Persicaria lanata, Lippia alba, Phyllunthus reticulatus, Ruellia tuberosa, Sida acuta are more available in the study area.

Calamus tenuis, Coix lacryma-jobi, Lasia spinosa, Tinospora crispa and *Passiflora foetida* are rarely found in study area. The number of these species is decreasing day by day. *Tinospora crispa* is a threatened species (Khan *et al.* 2001) which is a popular medicinal plant used by the local people.

Most common exotic plants of the study area were *Acacia auriculiformis* (Akashmoni), *Acacia nilotica* (Babla) and *Eucalyptus camaldulensii. Parthenium hysterophorus* was recorded as the poisonous exotic plant from sreenagar. The invasive alien species at aquatic habitats namely *Eichhornia crassipes, Alternanthera philoxeroides, Ipomoea aquatica* and *Pistia stratiotes* were found to prohibit the growth and dispersal of other aquatic species of the study area destroying the aquatic vegetation. During the field works some threats like destruction of natural habitats by the local people, lack of awareness, unsustainable collection, and river degradation were identified as active in the study area. The wetlands in the study area are brought under cultivating process during the dry season. As a result the aquatic vegetation of these wetlands seems to be diminished. Uses of excessive amount of fertilizers, insecticides, pesticides as well as herbicides are the other reasons for diminishing the natural aquatic vegetation of the study area. Several discussions with local people have been conducted on the conservation issues of angiosperm flora. A number of suggestions came out from such discussion are presented below: (A) Native plants should be selected for plantation. (B) Conservation of the threatened plant species by *in-situ* methods should be undertaken. The local people should be involved in this activity. (C) Awareness among the local people should be created. (D) Nursery should be developed for the propagation of threatened plants. (E) Government and local NGOs can act jointly for the conservation of angiosperm flora.

Acknowledgements

The authors are thankful to the Ministry of Science and Technology, Govt. of the People's Republic of Bangladesh for their funding. They are also grateful to the local people of Sreenagar *Upazila*, Munshiganj.

References

Ahmed, Z.U., Z.N.T. Begum, M.A. Hassan, M. Khondker, S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque (Eds) 2008a. *Encyclopedia of Flora and Fauna of Bangladesh*, Vol. **6**. Angiosperms: Dicotyledons (Acanthaceae – Asteraceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-408.

Ahmed, Z.U., M.A. Hassan, Z.N.T. Begum, M. Khondker, S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque, (Eds)2008b. *Encyclopedia of Flora and Fauna*

of Bangladesh, Vol. **12**. Angiosperms:Monocotyledons (Orchidaceae – Zingiberaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-552.

Ahmed, Z.U., Z.N.T. Begum, M.A., Hassan, M. Khondker, S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque (Eds) 2009b. *Encyclopedia of Flora and Fauna of Bangladesh* Vol. **7**. Angiosperms: Dicotyledons (Balsaminaceae – Euphorbiaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-546.

Ahmed, Z.U., Z.N.T. Begum, M.A., Hassan, M. Khondker, S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque (Eds) 2009c. *Encyclopedia of Flora and Fauna of Bangladesh* Vol. **8**. Angiosperms: Dicotyledons (Fabaceae – Lythraceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-478.

Ahmed, Z.U., Z.N.T., Begum, M.A., Hassan, M., Khondker, S.M.H., Kabir, M., Ahmad, A.T.A., Ahmed, A.K.A. Rahman and E.U. Haque (Eds) 2009d. *Encyclopedia of Flora and Fauna of Bangladesh* Vol. **9**. Angiosperms: Dicotyledons (Magnoliaceae – Punicaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-488.

Ahmed, Z.U., Z.N.T., Begum, M.A., Hassan, M., Khondker, S.M.H., Kabir, M., Ahmad, A.T.A., Ahmed, A.K.A. Rahman and E.U. Haque (Eds) 2009e. *Encyclopedia of Flora and Fauna of Bangladesh*, Vol. **10**. Angiosperms: Dicotyledons (Ranunculaceae – Zygophyllaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-580.

Alexiades, M. N. (ed.). 1996. *Selected Guidelines for Ethno botanical Research*: *A Field Manual*. The New York Botanical Garden, New York.

Ara, H., B. Khan and S. N. Uddin. (eds.) 2013. *Red data book of vascular plants of Bangladesh*, Vol 2. Bangladesh National Herbarium, Dhaka, Bangladesh. 280 pp

Bangladesh Bureau of Statistics 2011. Monthly Statistical Bulletin, December 2011. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Cronquist, A. 1981. *An integrated system of classification of flowering plants.* Columbia University Press, New York, pp. 1262

Hooker, J.D. 1872-1897. *The flora of British India*. Vol. **1-7,** London.

Hyland, B.P.M. 1972. A technique for collecting botanical specimens in rain forest. Flora Malesiana Bulletin, **26**: 2038-2040.

Khan, M.S., M.M. Rahman, A.M. Huq, M.M.K. Mia, and M. A. Hassan. 1994. Assesment of biodiversity of Teknaf game reserve in Bangladesh focusing on economically and ecologically important plants species. *Bangladesh J. Plant. Taxon.* **1**(1): 21-33.

Khan, M.S. and A.M. Huq 2001. The vascular flora of Chunati wildlife sanctuary in south Chittagong, Bangladesh. Bangladesh J. Plant.Taxon. **8**(1): 47-64.

Khan M.S., M.M. Rahman and M.M. Ali (eds.). 2001. *Red Data Book of Vascular Plants of Bangladesh.* Bangladesh National Herbarium. pp. 179

Khan, M.S., M.M. Rahman, A.M. Huq, M.M.K. Mia and M. A. Hassan. 1994. Assessment of biodiversity of Teknaf game reserve in Bangladesh focusing on economically and ecologically important plants species. *Bangladesh J. Plant. Taxon.* **1**(1): 21-33.

Prain, D. 1903. *Bengal Plant.* First Indian Reprint 1963, Bishen Singh Mahendra Pal Singh Dehra Dun. Vol. **1-2:** 1-1013 pp.

Rahman, M.A. and S.B. Uddin 1998. Some anti-rheumatic plants used by tribal people of Hill Tracts district. Biodiversity Newsletter, University of Chittagong. **2**(2): 4.

Rahman, M.O. and M. Begum, M.W. Ullah. 2013. Angiosperm flora of Sadar upazila of Munshiganj District Bangladesh. *Bangladesh J. Plant Taxon.* **20**(2): 213-231.

Rahman, M.O. and M.A. Hassan 1995. Angiospermic flora of Bhawal Narional Park, Gazipur, Bangladesh. *Bangladesh J. Plant Taxon.* **2**(1&2): 47-79

Rahman, M.O. and M.A. Hassan. 1995. Angiospermic flora of Bhawal Narional Park, Gazipur, Bangladesh. *Bangladesh J. Plant Taxon.* **2**(1&2): 47-79.

Sarker M. H. 2012. "Sreenagar Upazila" in Sirajul Islam and Ahmed A. Jamal, Banglapedia: National Encyclopedia of Bangladesh (Second ed), Asiatic society of Bangladesh.

Siddiqui, K.U., M.A. Islam, Z.U. Ahmed, Z.N.T. Begum, M.A. Hassan, M. Khondker, M.M. Rahman, S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A. Rahman and E.U. Haque (Eds) 2007c. *Encyclopedia of Flora and Fauna of Bangladesh*, Vol. **11**. Angiosperms: Monocotyledons (Agavaceae -Najadaceae). Asiatic Society of Bangladesh, Dhaka, pp. 1-399.

Uddin, M.Z, M.F. Alam, A.S.M. Rahman and M.A. Hassan. 2011. Plant Biodiversity of Fashiakhali Wildlife Santuary, Bangladesh. Accepted for publication in First Bangladesh Forestry Congress Proceeding.

Uddin, M.Z. and M.A. Hassan. 2004. Flora of Rema-Kalenga Wildlife Sanctuary. IUCN Bangladesh Country Office, Dhaka, Bangladesh, vi+120 pp.

Uddin, M.Z. and M.A. Hassan. 2010. Angiosperm diversity of Lawachara National Park (Bangladesh): a preliminary assessment. *Bangladesh J. Plant Taxon*. **17** (1): 9-22.

Uddin, S.B. and M.A. Rahman. 1999. Angiospermic flora of Himchari National Park, Cox's Bazar, *Bangladesh. J. Plant Taxon*. **6**(1): 31-68

Uddin, M.Z., M. F. Alam, M. A. Rahman and M. A. Hassan. 2013. Diversity in angiosperm flora of Teknaf Wildlife Sanctuary, Bangladesh. Bangladesh J. Plant Taxon. **20**(2): 145-162.

Uddin, S.N., M.S. Khan, M.A. Hassan and M.K. Alam 1998. An annotated checklist of angiospermic flora of Sitapahar at Kaptai in Bangladesh. *Bangladesh J. Plant Taxon.* **5**(1): 13-46.

Uddin, M. Z. and M. A. Hassan. 2010. Angiosperm diversity of Lawachara National Park (Bangladesh): a preliminary assessment. *Bangladesh J. Plant Taxon.* 17(1): 9-22.

Uddin, M. Z. and Md. Abiabdullah. 2016. Taxonomic study on the angiosperms of char kukri mukri wildlife sanctuary, Bhola district. *J. Asiat. Soc. Bangladesh, Sci.* **42**(2): 153-168.

(Revised copy received on 10. 11. 2017)

J. Asiat. Soc. Bangladesh, Sci. 43(2): 173-180, December 2017

DIVERSITY AND ANTIBIOTIC SUSCEPTIBILITY OF BACTERIA IN WATER OF HOTEL RESTAURANTS IN DHAKA CITY

MD. ABDUL KARIM[1] AND NASRIN SULTANA*
Laboratory of Microbiology, Department of Botany,
University of Dhaka, Dhaka 1000, Bangladesh

Abstract

Present study was conducted to determine the microbiological status of water from dispensers in different roadside hotel and restaurants of Dhaka city. Samples were collected from seven hotel and restaurants. Aerobic heterotrophic bacterial count ranged between 1.5 × 10 and 8.8 × 10^3 cfu/ml. Enteric and related bacterial abundance in MacConkey, SS and Cetrimide agar media ranged from 0 to 4.9 × 10^6, 0 to 2.1 × 10^5 and 0 to 1.2 × 10^6cfu/ml, respectively. In total, 28 bacterial isolates were obtained during the study period. Among them, 15 were heterotrophic isolates and 13 were enteric and related bacteria. Among 15 aerobic heterotrophic isolates, 11 were gram positive and five were gram negative. Out of 11 gram positive isolates, 7 belonged to the genus *Bacillus viz. B. circulans, B. subtilis, B. stearothermophilus, B. brevis* and *B. cereus* and one to coccus *viz. Micrococcus roseus*. The other gram positive species were *Kurtia gibsonii, Auriobacterium liguefaciens* and *Curtobacterium luteum*. Four gram negative isolates were *Neisseria elongate* sub. spp. *glycolytica, Plesiomonas shigelloides, Pseudomonas fluorescens* biovar 1, *Pseudomonas aeruginosa*. All 13 enteric and related isolates were gram negative, short rod; and non-spore formers and belonged to the genera *Escherichia, Klebsiella, Shigella* and *Pseudomonas*. Among all isolates, two were resistant and six were susceptible to all five antibiotics.

Key words: Bacteria, Drinking water, Hotels, Restaurant, Dhaka city, Antibiotic resistant

Introduction

Transmission of pathogens through contaminated water is a significant cause of illness worldwide. It has been estimated that one-third of gastrointestinal illnesses are caused by contaminated drinking water (Hunter 1997), and 4% of all deaths worldwide are due to polluted drinking water and poor sanitation (Prüss *et al*. 2002). In developed nations water quality assessments and treatment facilities have been introduced to reduce microbial contamination, resulting in a significant reduction in drinking water-related illnesses and deaths. Water treatment commonly involves the reduction of organic matters and other contaminants via coagulation and sedimentation, separation of any remaining solids via filtration and finally disinfection using chemical oxidants or ultraviolet (UV) radiation. The addition of chemical oxidants such as chlorine and mono-chloramine is the most common method of drinking water disinfection (USEPA 1999).

* Corresponding author

The level of treatment required varies from system to system, with some drinking water distribution systems receiving only one or two levels of treatment, while others require multiple treatments to create water suitable for end use.

Some members of the total coliform group are considerably more resistant to disinfection than *E. coli* and are better indicators of poor disinfection (WHO 2004 and Fricker and Eldred 2009). The presence of total coliforms in a water distribution system can also indicate a lack of system integrity (Besner *et al*. 2002). Thus, total coliform bacteria are commonly used to evaluate the general sanitary quality of water (WHO 2004 and Fricker and Eldred 2009).

Outbreaks of water borne diseases continue to occur throughout the world but especially serious in developing countries (WHO 1993 and Reynolds *et al*. 2007). Diarrheal diseases are endemic in Bangladesh. In 2008, an estimated 20,000 children less than 5 years old died of diarrheal diseases in Bangladesh (Huda *et al*. 2012). *E. coli* is commonly isolated from water sources, including the municipal water supply of Dhaka city (Islam *et al*. 2010). One study from India and another from Canada also reported the presence of antibiotic resistant *E. coli* in drinking water (Coleman *et al*. 2012 and Pathak and Gopal 2008). Armstrong *et al*. (1981) found that multiply antibiotic resistant (MAR), Gram positive cocci, e.g. *Staphylococcus* and MAR gram negative, non-fermentative rods *Pseudomonas*, *Alcaligenes*, *Moraxella*-like group M and *Acinetobacter* were more common in drinking waters than in untreated source waters.

According to the WHO guideline values for bacteriological quality, all water intended for drinking and treated water in the distribution system should not have detectable levels of *E. coli* or thermo-tolerant coliform bacteria in any 100 ml of the water sample (Sobsey and Bartram 2003). Unlike cholera, humans infected with salmonellae can carry the bacteria in the gut without signs of disease. Infected humans can harbor the bacteria for considerable periods of time. About 5% of patients clinically cured from typhoid fever remain carriers for months or even years. These people can be chronic holders of the bacterium in the gut, and constitute the main reservoir of the bacteria in the environment (Popoff and Le Minor 2005). Shigellosis or Bacillary dysentery is also an important waterborne disease which is an infectious disease caused by a group of bacteria called *Shigella*.

Dhaka is the 9thlargest city and also 28thamong the most densely populated cities in the world. Everyday lots of people take their meals from roadside hotel and restaurants. Besides high cost bottle water, low cost dispenser water is now very popular. The present study was undertaken for enumeration of both heterotrophic and enteric bacteriological abundance and comparison microbial abundances among those hotels and restaurants situated in Dhaka city.

Materials and Methods

Study site and sampling: In the present study water samples were collected from seven hotel restaurants in Dhaka city during the period from April 2013 to March 2014. Sterile plastic bottles were used for sample collection. Industrially prepared drinking water supplied to these restaurants were collected during sampling period.

Isolation of bacteria: Nutrient agar (NA) medium was used for the enumeration and isolation of aerobic heterotrophic bacteria, while MacConkey agar (Difco), SS agar (Diagnostic Pasteur), Cetrimide agar (Difco) media were used for the determination and isolation of enteric bacteria present in water samples. The pH of the medium was adjusted to 7, since pH of most of the samples were within the range of 6.58-6.95. Three different techniques *viz.* Pour plate technique (Greenberg *et al.* 1998), Spread plate technique (Sharp and Lyles 1969), Membrane filtration technique (Atlas *et al.* 1995) were used for the enumeration and isolation of bacteria. All the culture plates were marked with sample name and incubated at 37 °C in the dark for 48 hours. Bacterial colony counting was made with the help of a digital colony counter (DC-8 OSK 100086, Kayagaki, Japan). Discrete bacterial colonies were isolated immediately after counting. In case of MacConkey agar medium, pink or brick red colonies were considered as coliform bacteria while white colonies were considered as non-lactose fermenter, whereas in SS agar medium, black colonies were considered as highly pathogenic. In cetrimide agar medium, green colonies were considered *Pseudomonas* and pathogenic. During this investigation, of the total 40 isolates from nutrient agar medium, finally 28 isolates were randomly selected and purified for detailed study required for identification.

Physico-chemical properties of water: Temperature of Water samples was measured by a mercury centigrade thermometer.

(After collection of samples) pH was measured in the laboratory by an electric pH meter (Jenway 3310 pH meter, U.K).

Antibiotic sensitivity test: Five common antibiotics *viz.* Doxycycline. Penicillin G, Erythromycin, Gentamycin and Streptomycin were used to carry out the antibiotic sensitivity test.

Identification of bacteria: Important physiological and biochemical characteristics were studied for the identification of the selected isolates. Bergey's Manual of Systematic Bacteriology (Sneath *et al.* 1986) was followed for the identification of aerobic heterotrophic bacteria while, Manual for laboratory investigations of acute enteric infections (WHO 1987) and Bergey's manual of systematic bacteriology (Krieg and Holt 1984) were consulted for gram negative, enteric and related bacteria.

Results and Discussion

The physico-chemical properties of the samples are presented in Table 1. The water temperature ranged between 19ºC and 28ºC.Minimum water temperature was 19ºC recorded in sample No. 5. Maximum was 28ºC recorded in the sample No. 2 and sample No. 7. The pH of the sample water ranged between 6.58 and 6.95. Sample No. 7 showed the highest pH value (6.95) while the lowest pH value (6.58) was recorded in sample No. 6.

Table 1. Water temperature and pH of different samples.

Sample No.	Sampling sites	Water temperature (ºC)	pH
1	Star hotel and kabab	23	6.68
2	Rajdhani hotel and restaurant	28	6.60
3	Pita ghor hotel and restaurant	20	6.68
4	Al–Arju hotel and restaurant	25	6.90
5	Sayedabad hotel and restaurant	19	6.66
6	Hotel Kisukkhon	25	6.58
7	Allah'r dan hotel and restaurant	28	6.95

Table 2. Bacterial count (cfu/ml) of the water samples of different hotel restaurants.

Sample No.	Sampling sites	Aerobic heterotrophic bacteria	Enteric and related bacteria		
			MacConkey agar	SS agar	Cetrimide agar
1	Star hotel and Kabab	7.9×10^{2}	NG	NG	NG
2	Rajdhani hotel and restaurant	1.1×10^{3}	3.2×10^{2}	NG	NG
3	Pita ghor hotel and restaurant	8.8×10^{3}	1.8×10^{2}	2.0×10^{1}	NG
4	Al-Arju hotel and restaurant	1.3×10^{3}	3.0×10^{1}	1.8×10^{5}	1.2×10^{6}
5	Sayedabad hotel and restaurant	1.0×10^{3}	8.0×10^{1}	2.0×10^{1}	NG
6	Hotel Kisukkhon	1.5×10^{1}	2.4×10^{1}	1.7×10^{1}	4.1×10^{1}
7	Allah'r dan hotel and restaurant	1.1×10^{3}	4.9×10^{6}	2.1×10^{5}	NG

NG = No growth.

Aerobic heterotrophic bacterial count was higher than the count of enteric and related bacteria (Table 2). Aerobic heterotrophic bacterial count ranged between 1.5 × 10 and 8.8 × 10^{3} cfu/ml. In SS agar average bacterial count varied from 0 to 2.1 × 10^{5} cfu/ml. Bacterial count on MacConkey agar ranged between 0 and 4.9 × 10^{6}cfu/ml. In cetrimide agar medium bacterial count was within the range of 0 to 1.2 × 10^{6} cfu/ml and among the seven samples, 5 samples showed no bacterial growth (Table 2). Out of 15 selected

isolates, PG 11 and PG 23 were resistant, while RH 11, AD 11, SK 41, PG 21, RH 13 and HK 11 were susceptible to all five selected antibiotics (Table 3).

Table 3. Antibiotic sensitivity of the selected isolates.

Isolate No.	Inhibition zone measured in diameter (mm)				
	Name of the Antibiotics				
	E-15	P-10	GEN-10	S-10	DO-30
AD-10	R	R	S (18)	R	S (14)
PG-11	R	R	R	R	R
PG-22	S (20)	S (15)	S (29)	S (14)	S (20)
PG-23	R	R	R	R	R
RH-11	S (25)	S (12)	S (16)	S (12)	S (21)
AA-11	S (08)	R	S (22)	S (14)	S (10.5)
AA-13	R	R	S (22)	S (19)	S (11)
AD-11	S (24)	S (02)	S (19)	S (21)	S (15)
SK-41	S (13)	S (18)	S (13)	S (17)	S (17)
PG-21	S (21)	S (09)	S (17)	S (12)	S (19)
RH-13	S (12)	S (08)	S (14)	S (16)	S (14)
AA-12	S (03)	R	S (21)	S (21)	S (14)
SH-11	R	R	S (21)	S (14)	S (02)
SK-11	R	R	S (14)	R	S (18)
HK-11	S (14)	S (01)	S (14)	S (11)	S (15)

S = Sensitive, R = Resistant, E-15 = Erythromycin, P 10 = Penicillin G,
S-10=Streptomycin, GEN-10 = Gentamycin, N30 = Doxycycline.

Consulting all observed and tested characters of the bacterial isolates, identification was done. Ninety eight bacterial isolates were obtained during the study period. Among them 15 were heterotrophic isolates and 13 were enteric and related bacteria (Table 4). From the 15 aerobic heterotrophic bacteria 11 were gram positive bacterial isolates of which 7 belong to the genus *Bacillus* and one gram positive bacterial isolate to *Micrococcus.* Under the genus *Bacillus* the provisionally identified species were *Bacillus circulans* (two isolates), *Bacillus subtilis*, *Bacillus stearothermophilus*, *Bacillus brevis* and *Bacillus cereus* (two isolates). The four heterotrophic gram negative bacterial isolates were *Neisseria elongate* sub. spp. *glycolytica*, *Plesiomonas shigelloides*, *Pseudomonas fluorescens* biovar 1 and *Pseudomonas aeruginosa*. All 13 enteric and related isolates were gram negative, short rod and non-spore former and belonged to the genera *Escherichia coli*, *Klebsiella*, *Shigella* and *Pseudomonas*.

Table 4. Provisional identification of the selected bacterial isolates.

Isolate No.	Source (sample no.)	Species identified	
		Gram positive	Gram Negative
AD-10	7	*Aureobacterium liquefaciens*	–
PG-11	3	*Kurtia gibsonii*	–
PG-22	3	*Bacillus stearothermophilus*	–
PG-23	3	*Bacillus brevis*	–
RH-11	2	*Bacillus subtilis*	*Escherichia coli*
RH-17	2	–	*Klebsiella* sp.
AA-11	4	*Bacillus cereus*	–
AA-13	4	*Curtobacterium luteum*	–
AA-02	4	–	*Escherichia coli*
AA-18	4	–	*Shigella* sp.
AD-11	7	*Bacillus cereus*	–
AD-06	7	–	*Escherichia coli*
AD-14	7	–	*Shigella* sp.
SK-41	1	*Bacillus circulans*	–
PG-21	3	*Bacillus circulans*	–
PG-06	3	–	*Escherichia coli*
PG-02	3	–	*Shigella* sp.
RH-13	2	–	*Neisseria elongate* subspp *glycolytica*.
AA-12	4	–	*Plesiomonas shigelloides*
AA-03	4	–	*Pseudomonas aeruginosa*
SH-11	5	–	*Pseudomonas fluorescens* biovar 1
SH-21	5	–	*Escherichia coli*
SH-25	5	–	*Shigella* sp.
SK-15	1	–	*Pseudomonas aeruginosa*
HK-11	6	*Micrococcus roseus*	–
HK-05	6	–	*Pseudomonas aeruginosa*
HK-19	6	–	*Escherichia coli*
HK-22	6	–	*Shigella* sp.
AD-18	7	–	*Klebsiella* sp.

According to "WHO guidelines for drinking water quality", *Escherichia coli* (fecal coliform bacilli) must not be present in any 100 ml sample of (1) all water directly intended for drinking, (2) treated water entering the distribution system and (3) treated water in the distribution system. For effective disinfection, there should be a residual concentration of free chlorine of ≥ 0.5 mg / litre after at least 30 min contact time at pH <0.8. Chlorine residual should be maintained throughout the distribution system. At the point of delivery, the minimum residual concentration of free chlorine should be 0.2 mg/litre. The guideline value for chlorine used in water treatment that is of health significance in drinking-water is 5.0 mg / litre (WHO 2008). The results clearly showed that all the samples except sample no. 1 contaminated with *E coli*, *Shigella* sp., *Pseudomonas* and *Klebsiella* sp., which are pathogenic for human health. All the samples

showed presence of high number of bacteria as revealed by heterotrophic plate count, which is far beyond the limit set by WHO and USEPA for drinking water considered to be safe to public health.

References

Armstrong, J.L., D.S. Shigeno, J.J. Calomiris and R.J. Seidler. 1981. Antibiotic-resistant bacteria in drinking water.*Appl. Environ. Microbiol.* **42**(2): 277-283.

Atlas, R.M., A.E. Brown and L.C. Parks. 1995. *Laboratory Manual of ExperimentalMicrobiology*. Mosby-Year Book, Inc., St. Louis. pp. 1-565.

Besner, M-C., V. Gauthier, P. Servais and A. Camper. 2002. Explaining theoccurrence of coliforms in distribution systems. *J. AWWA* **94**:95–109.

Coleman, B.L., M.I. Salvadori, A.J. McGeer, K.A. Sibley and N.F. Neumann. 2012. The role of drinking water in the transmission of antimicrobial resistant *E. coli.Epidemiology and Infection* **140**: 633-642.

Fricker, C.R. and B.J. Eldred. 2009. Identification of coliform genera recoveredfrom water using different technologies. *Lett. Appl. Microbiol.* **49**: 685–688.

Greenberg, A.E., J.J. Connors, D.G.J. Jenkins and M.A.H. Franson. 1998. *Standard methods for examination of water and wastewater* (20th Ed.). APHA. Washington DC. p. 265.

Huda, T.M., L. Unicomb, R.B. Johnston, A.K. Halder, M.A.Y. Sharker. 2012. Interim evaluation of a large scale sanitation, hygiene and water improvement programme on childhood diarrhea and respiratory disease in rural Bangladesh. *Social Science & Medicine* **75**: 604–611.

Hunter, P.R. 1997. *Waterborne disease: epidemiology and ecology*. John Wiley and Sons, Chichester, United Kingdom.

Islam, S., H.A. Begum and N.Y. Mili. 2010. Bacteriological Safety Assessment of Municipal Tap Water and Quality of Bottle Water in Dhaka City: Health Hazard Analysis. Bangladesh.*J. Med. Microbiol.* **4**(1): 9-13.

Krieg, N.R. and J.G. Holt (Eds.). 1984.*Bergey's Manual of Systematic Bacteriology*. The Williams and Wilkins Company, Baltimore, USA. Vol.1: pp. 140-575.

Pathak, S.P., K. Gopal. 2008. Prevalence of bacterial contamination with antibiotic resistant and enterotoxigenic fecal coliform treated drinking water. *J. Toxicol. Environ. Health* **71**: 427-433.

Popoff, M.Y. and L.E. Le Minor. 2005. Genus *Salmonella*. *In*: *Bergey's Manual of Systematic Bacteriology* (2nd Ed), Vol. 2, Part B. Brenner, D.J., N.R. Krieg, J.T. Staley, G.M. Garrity, D.R. Boone, P.D. Vos, M. Goodfellow, F.A. Rainey and K.H. Schleifer (Eds). Springer.NY. pp. 764–799.

Prüss, A., D. Kay, L. Fewtrell and J.Bartram. 2002. Estimating the burden ofdisease due to water, sanitation and hygiene at a global level. *Environ Health Perspect*. **110**: 537–542.

Reynolds, K.A., K.D. Mena and C.P. Gerba. 2007.Risk of water-borne illness via drinking water in the United States.*Rev. Environ.Contam.Toxicol.* **192**: 117-158.

Sharp, M.S. and S.T. Lyles. 1969.*Laboratory Instruction in Biology of Microorganisms*.Saint Louis the CV Mosley Company. pp. 23-25.

Sneath, P.H.A., N.S. Mair, M.E. Sharpe and J.G. Holt (Eds.). 1986. *Bergey's manual of systematic bacteriology* (9thEd.). The Williams and Wilkins Co., Baltimore, USA. Vol. 2, p. 1599.

Sobsey, M.D. and S. Bartram. 2003. Water quality and health in the new millennium: the role of the World Health Organization Guidelines for Drinking-Water Quality. *Forum Nutr.* **56**: 396-440.

USEPA. 1999. *EPA guidance manual*: alternative disinfectants and oxidants, EPA 815-R-99-014. US Environmental Protection Agency, Washington, DC.

WHO. 1987. *Manual for laboratory investigations of acute enteric infections.*World Health Organization p. 1-109.

WHO. 1993. *Guidelines for drinking water quality* (Vol. 1). World Health Organization, Geneva. pp 1-29.

WHO. 2004. Guidelines for drinking-water quality, (3rd ed.), Vol 1. Recommendations. *World Health Organization*, Geneva, Switzerland.

WHO. 2008. *Guidelines for drinking-water quality*, (3rd Ed.). (Incorporating first & second addenda), Vol. 1 - Recommendations, Geneva.

(Revised copy received on 4-11-2017)

J. Asiat. Soc. Bangladesh, Sci. 43(2): 181-195, December 2017

MULTI-HAZARD VULNERABILITY ASSESSMENT OF AN URBAN AREA: A CASE STUDY ON WARD 34 OF DHAKA SOUTH CITY CORPORATION

M. MAKSUDUR RAHMAN[*1], SHAMIMA AKTAR[2] AND MD. ASHIKUZZAMAN[3]
[1]*Department of Geography and Environment, University of Dhaka, Dhaka 1000, Bangladesh*
[2]*WorldFish, Bangladesh,* [3]*Development Studies Discipline, Khulna University, Khulna 9208, Bangladesh*

Abstract

Multi-hazard assessment provides the scope to understand the vulnerability situation of any area based on different hazard context. This study was conducted in one ward of Dhaka city corporation area to examine its multi-hazard vulnerability. Three key potential hazards: fire, earthquake and water-logging were considered to implement the multi-hazard analysis framework. To perform the analysis entire study area was surveyed and examined applying Geographic Information System in terms of practicing planning rules and regulation of Government of Bangladesh. All the structures of the study area were assessed and categorized into four classes ranging from severe to none according to some vulnerability criteria defined by safety standards. Individual vulnerability analysis was performed to realize the hazard specific vulnerability context. Finally, single processed hazard maps were combined to examine the multi hazard vulnerability of this study area. These findings denote that there are a certain number of structures in very risk position which should receive immediate hazard mitigation measures.

Key words: Multi-hazard, GIS, Vulnerability, Urbanization, Planning Standard, Fire, Earthquake, Water-Logging

Introduction

Urbanization and rapid population growth lead to the concentration of population in hazard and risk prone urban areas, both in mega cities and in small and medium sized urban center although it is the size, number, functions and geographical distribution of medium to large and mega cities that create a major concern for disaster risk (Gencer 2013). The interconnection between natural and human influenced disasters has made the hazard assessment system more holistic that consider all the potential vulnerable factors than counting single events. Many hazards can be caused by the same events. Assessment and mitigation of the impact of catastrophic events in a given area require innovative approaches allowing a comparison of different risks and accounting for all the possible cascade events (Marzocchi *et al*. 2009). The multi hazard assessment (MHA) is an excellent tool to create awareness in mitigating multiple hazards. It becomes a comprehensive analytical tool for assessing vulnerability and risk to develop an integrated emergency preparedness response and recovery procedures (OAS 1991).

[*]Corresponding author: mmrahman2000bd@yahoo.com

The geographical setting of Bangladesh has made this country vulnerable to many natural hazards. Situation becomes worst when it merges with manmade disasters especially in the urban areas. With the advancement of urbanization cities are deliberately shifting towards vertical direction to cope with the extensive population pressure. The unplanned and uncontrolled construction of high rise buildings, paved roads and markets are emerging as risk factor for the urban dwellers. Many of those were constructed without following planning rules and regulations which cause needless human suffering and economic losses. This study intends to analyze this hazard situation of an urban setting from planning perspective considering all potential hazards experienced in previous years.

The study aims to analyze hazard specific vulnerability situation of the study area considering the potential hazards. Three main hazards of the study area: fire, earthquake and water logging were considered to conduct multi hazard assessment on the basis of different vulnerability criteria. Here, the vulnerability criteria have been chosen mainly from planning views.

Materials and Methods

Multi Hazard Assessment (MHA) becomes an influential tool to the decision makers for future planning initiatives because it can provide a composite hazard profile for the target area. To perform this assessment it is required to prepare individual hazard analysis that might cause risk to that region. In this study attempts were taken to analyze three hazards as fire, earthquake and water logging individually that ultimately provide the composite vulnerable situation of the study area. In compliance to authentic secondary information individual buildings were also surveyed to assess their vulnerability situation in accordance to several practicing planning rules of Bangladesh. Specific vulnerability criteria for each hazard were specified based on safety standard applicable for urban areas. Weightage and scoring methods were applied to analyze the vulnerability of structures which were finally described in hazard maps developed in ARCGIS. The individual hazard vulnerability was assessed in scale 0-3 (Table 1).

Table1. Hazard wise vulnerability score of fire/earthquake/water-logging.

Scale	Score
Severe	3
Moderate	2
Light	1
None	0

The individual results were then accumulated in one single map to get multi hazard picture. The interconnectivity between earthquake and consequent fire event influences to develop a hazard map for these two hazards. Finally, a multi hazard map describing vulnerable situation for these three major hazards was developed. This map has divided

the area into four vulnerable zones as severe, moderate, light and none based on their vulnerable situation.

Study Area

Dhaka, the capital city of Bangladesh, is renowned not only because of its huge population, but also in terms of economy, trade, commerce and administrative facilities. Megacity Dhaka is an agglomeration of Dhaka South City Corporation (DSCC), Dhaka

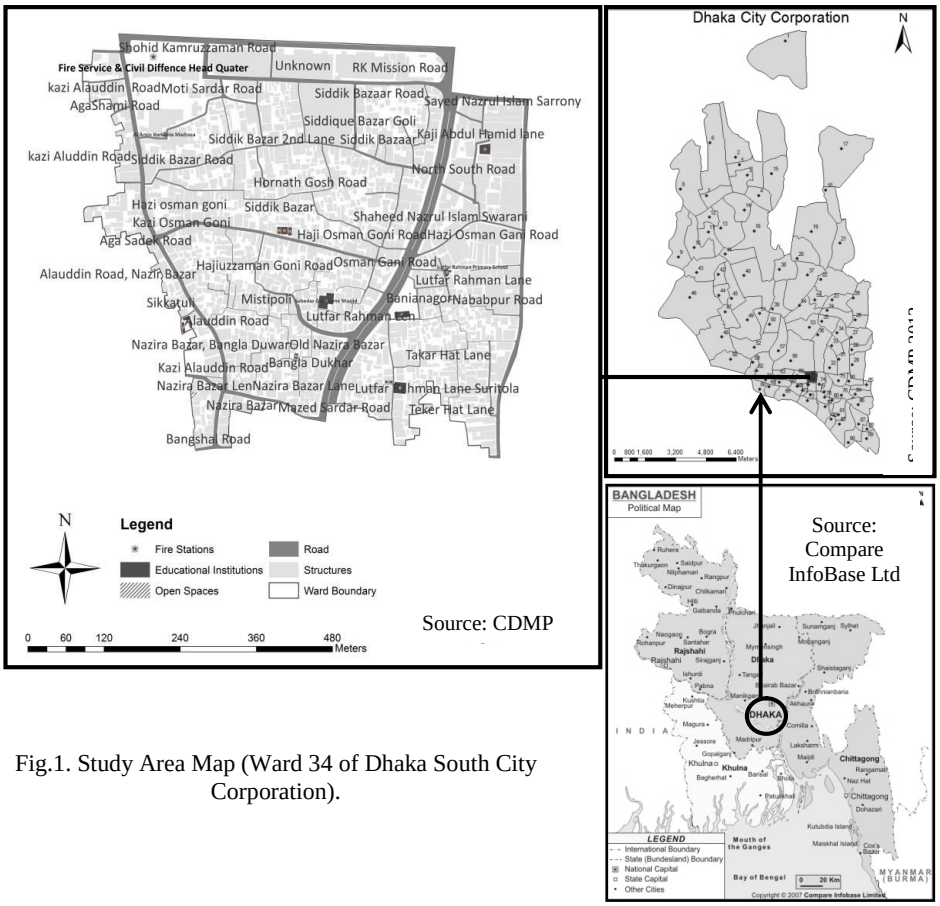

Fig.1. Study Area Map (Ward 34 of Dhaka South City Corporation).

North City Corporation (DNCC), four other municipalities (Narayanganj, Tongi, Gazipur and Savar), several cantonments and a large number of rural settlements, stretches of agricultural lands, wetlands, rivers, and even part of the Modhupur forest (Islam 1998). This study was conducted in ward no. 34 of Dhaka South City Corporation (DSCC) area (Fig. 1). The ward includes Siddique Bazar, Taker Hat Lane, Nowabpur Road, Hazi

Osman Goni Road, Nazira Bazar Lane, Lutfor Rahman Lane, Kazi Abdul Hamid Lane, Kazi Alauddin Road and Fulbaria Puraton Railway Station (Kotowali Part) (Fig. 1). Total area is about 0.37 sq km with a population of 50624 (BBS 2014). To keep pace with the increasing demand new buildings are emerging by demolishing old structures. This mixed used area is characterized by both old and new structures surrounding narrow and congested old roads (Khatun 2003). Most of the buildings are used for multipurpose including residential, industrial and market which poses great risk to live and livelihood. Violation of rules increases the vulnerability to fire and earthquake hazard. Moreover, unplanned urbanization results in water logging that makes the lives of the inhabitants miserable.

Results and Discussion

Hazard specific vulnerability criteria were fixed to analyze the potential hazard of the study area. Based on the result the multi-hazard vulnerability was assessed.

Fire Hazard Vulnerability: Fire is always ranked as top most vital hazard for any urban area. It poses devastating impacts on communities. Several factors like unplanned urbanization, high population density, lack of following safety codes, lack of proper monitoring and development strategy etc. causes fire event in an urban area. In Dhaka, fire is quite a predictable risk factor especially for high-rise buildings in mixed used areas that constructed violating safety codes (Islam and Adri 2008).

The building owners of Bangladesh are bound to follow the building construction rules amended in 1996. This rule imposes conditions on setbacks, site coverage, plot usage etc. that ensures building safety during different hazards. Set back defines the optimum distance that a structure should maintain from adjacent road and other structures to offend spreading hazard effect. In case of fire event this distance plays a very crucial role. The shorter the distance the structures are more vulnerable to catch up with fire from nearby sources. According to building construction rule 1996 at least 1.80 m (to some cases it can be 2.00 m or more based on plot size) have to be unoccupied to keep buildings safe. So, buildings were identified into five cases based on buffer distance as 0.5 m, 1.00 m, 1.50 m, 2.00 m and more than 2.00 m to measure potential vulnerability of the study area in terms of susceptibility to spread fire event. The study found about 87.67% structures have space less than or equal to 1.5 m space that does not follow the minimum standard defined by GoB.

To asses fire hazard vulnerability access to road is always considered as one of the important factors. Death tolls goes higher if fails to control at the right moment where access roads provides the opportunity to get escape as well as access to rescuers. In the study area a good percentage of structures has limited and even no access to roads (Field Survey 2013). The residents of this area use man made walkway or even balcony and courtyard of adjacent structures to access their living place. It increases the vulnerability

of losses due to fire hazard. Previous experience of fire hazard in older part of Dhaka city proves this statement (Islam and Adri 2008 and Roy 2011). Many people get trapped within their structures during fire event. Moreover, fire control equipment cannot reach to them only because of lack of access road. The field observation states that structures having access road at least 10 m distance provide them the opportunity to get escape from their place but only presence of access road does not represent low fire hazard vulnerability. According to Building Construction Rules, 1996 every site has to be accessible to road having width minimum 3.65 m which can be 3.00 m width in case of private own land that ensure easy access to people and vehicle. According to fire service and civil defense (FSCD), in Bangladesh at least 3.05 m (10 ft) road width is needed to access fire control car. Thus structures were identified as having access to road with 3m width or not. The field survey states that the main roads have width more than or equal to 3 m but inner roads hardly meets the requirements. The study revealed that about 25.43% of the roads having width only 1 m. Some places were even found where people cannot bring their furniture within their home due to narrow road width. They bring raw wood and make furniture within their living space. From this scenario the condition of ward no 34 in DSCC can be realized. If fire hazard occurs in these places it is quite impossible for fire control car to reach. In this case fire control pipe or pump is used which needs more time to control fire event and thus existence of narrow roads certainly increases vulnerability to fire.

Ward no 34 in DSCC is basically a residential area but intrusion of various kind of usage has transformed the area as a mixed-up one. A single structure is used for different purposes like residence and retail, residence and industries, garments and hospital etc. which increase fire hazard vulnerability. Study revealed that only 50% of the structures are solely used for residential purpose and the rest are accounted for commercial, educational and even industrial activities and many of them handle highly flammable ingredients as raw materials. The primary information collected from Fire Service and Civil Defense (FSCD) provides the data for fire events that happened in last year in the study area. According to their information most of the fire events ignites from chemical, leather and shoe factories due to using chemical and glue which are highly sensitive to fire. Besides, the previous experience states that the hazardous structures used as garments, workshop and storage are also vulnerable for fire hazard in terms of both source and spreading perspective (Roy 2011). The highly flammable material used for these activities can easily spread fire. Buildings located nearby to these sources are considered as highly vulnerable to fire events.

Beside these vulnerable structures electricity supply sources may also appear as potential fire source if not follow safety rules. According to Electricity Rules, 1937 every conductor of an aerial line shall be inaccessible either from ground or from any building or structure, whether permanent or temporary except by the aid of a ladder or other special appliance (Electricity Rules 1937). That means, a safe distance has to be kept

from electric pole to avoid fire incidence. Buildings were surveyed based on distance maintained between structure and electric pole and vulnerability score were given.

The vulnerability situation for fire hazard was then analyzed by applying some score (Table 2) as given below:

Table 2. Fire hazard vulnerability score.

Criteria	Weightage	Sub-criteria	Score
Distance from Hazardous Building (HB)	6	Hazardous Structure	3
		Structure within 15m from Hazardous Structure	2
		Other Structure	1
Space between Structures (ST)	5	Space less than or equal to 0.5 m	5
		Space more than 0.5 m to/equal to 1.00 m	4
		Space more than 1.00 m to/equal to 1.50 m	3
		Space more than 1.50 m to/equal to 2.00 m	2
		More than 2 m	1
Distance from Electric Pole (EP)	4	Structures within 1m	4
		Structures within 2m	3
		Structures within 3m	2
		Structures within 4m	1
		Distance more than 4m	0
Proximity to Roads (PR)	3	Roads within 10m	1
		Roads within 15m	2
		Roads within 20m	3
		Distance more than 20m	4
Width of Access Road (WR)	2	Accessible	1
		Not Accessible	2

Here, the weightage score was assigned based on their significance to ignite and increase the intensity of fire events. Expert opinion was also considered while assigning this value. In this analysis scale was chosen as 1 equals to low and 6 equals to high value. A rank value for sub-criteria was also assigned to understand the vulnerability situation of each structure that ranges from 0 to 5 where zero means the building is not vulnerable to fire hazard whereas 5 indicates the high susceptibility to fire. Based on weightage and ranking value Fire Hazard Vulnerability (FHV) Score was calculated as:

FHV= (6 x Score of HB) + (5 x Score of ST) + (4 x Score of EP) + (3 x Score of PR) + (2 x Score of WR)

Finally, all the structures were categorized as severe, moderate and light vulnerable in terms of fire hazards. None of the buildings was found which show zero vulnerability. According to the analysis only 2.03% of the structures are at great danger. Certainly, it is good for the area that the proportion of severe vulnerable categories is less significant. However, approximately 60.44% and 37.53% structures were also identified as moderately and lightly vulnerable respectively. The situation can be well described from Fig. 2.

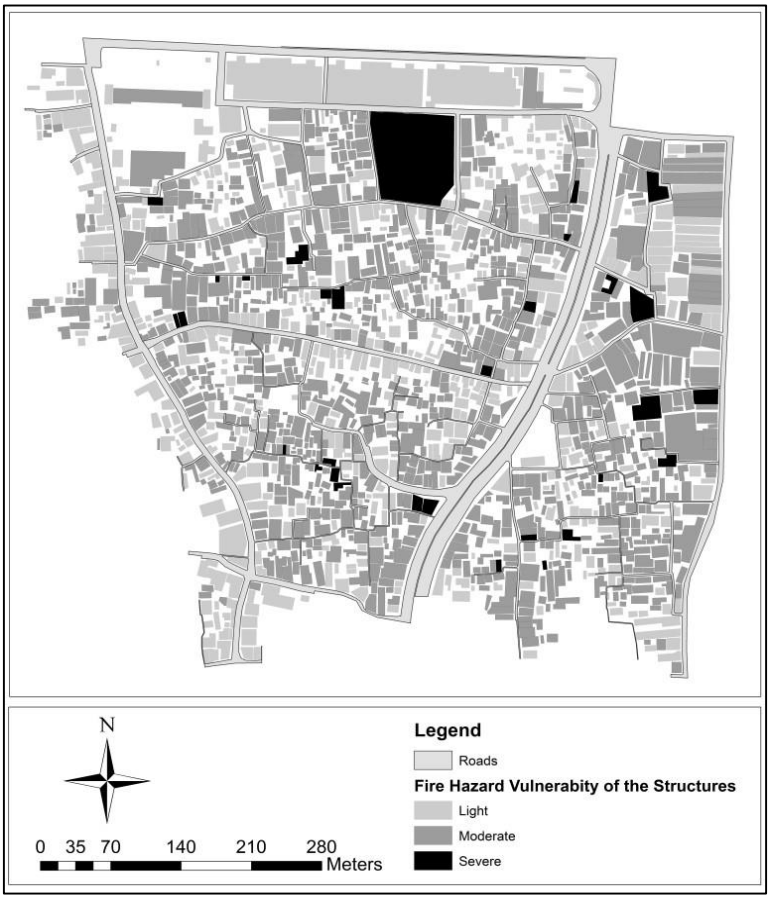

Fig.2. Fire Hazard Vulnerability Assessment (Source: Field Survey 2013).

Earthquake Hazard Vulnerability: The geographical and topographical setting of Dhaka makes it vulnerable to earthquake hazard. Unplanned urbanization with high population density can turn the situation to its worst. A study conducted by Cardona *et al*. (2001) ranked Dhaka city as one of the highest values of earthquake disaster risk index (EDRI) among other twenty cities in the world mainly due to its inherent vulnerability of building infrastructure.

The total number of floors above the ground level is one of the most important factors to measure earthquake vulnerability. From the previous earthquake experiences it has been estimated that the proportion of severely damaged structures increases steadily with building height which follow negative trend for the low rise structures. Here, age of building also describes the vulnerability situation of any structure. As time passes buildings start to decline its strength and fail to resist any earthquake force which is significantly important for high-rise structures. In this area, about 4.73% structures were

built before 1960 having height 1-6 stories which are extremely vulnerable to earthquake hazard. There are still some (1.57%) buildings which are more than 90 years in age. Among those about 0.14% structures have 4 stories which indeed show high vulnerability to earthquake.

In recent time, people are interested to go for vertical expansion which may also bring danger if proper rules are not followed during planning and construction. Many buildings of ward no 34 in DSCC were found to have heavy overhang, short column and soft story. In earthquake engineering these irregular shapes are considered undesirable because they cause an inappropriate dynamic behavior when subjected to horizontal earthquake ground motion (CDMP 2009 and Sucuoglu and Yazgan 2009). Limited building space insists people to ensure the maximum use of their land which results in heavy overhang part of their structure. Besides, some architectural design allows overhang to increase the aesthetic appearance. In the study area there are about 559 (33.35%) structures found having overhang section. Generally, commercial places keep some vacant places at ground level for the easy movement of people which is covered from second floor through heavy overhang. In case of residential structures people use this part as balcony, open space, small room and some other purposes. Some buildings were found to have their overhang part far beyond the plot boundary which is totally illegal from planning perspective and restricted by law. Similar to heavy overhang section short column is also a common practice in ward 34 in DSCC. About 26.68% structures observed having short column that attract several times larger earthquake force and suffer more damages compared to taller ones. There are also about 32.68% structures found with soft story. Soft story usually exists in a building when the ground story has less stiffness and strength compared to the upper stories. Many buildings with soft stories were observed to collapse in the past earthquakes all over the world (CDMP 2009, Sucuoglu and Yazgan 2009 and Sadat *et al*. 2010).

The lack of sufficient clearance between adjacent buildings allows them to pound together due to different vibration periods and consequent non-synchronized vibration amplitudes of earthquake. The foundation of building moves back and forth with the ground when experiences earthquake vibrations and the upper edges of the building swing from a few mm to many inches depending on their height size and mass. This may happen for buildings of all height but higher stories pose more damage (NZSEE 2006). In the study area there are about 38.54% structures show less than 0.5 m distance from adjacent buildings which may have the great potentially to have pounding effect during earthquake.

There is also a close relationship between apparent building quality and building damage. In most of the cases poor quality buildings show poor performance during earthquake. Quality building material and proper maintenance system determine the apparent building quality of any structure. For this study buildings were classified as good (have good strength and look lucrative), moderate (have moderate strength and maintenance works

perform occasionally) and poor (have weak strength and no/seldom performs maintenance/repairing works). Following this criteria there are about 35.44%, 46.48% and 18.08% structures in good, moderate and poor quality respectively.

Ground motion intensity may increase on top of hills due to topographic amplification during earthquake. The methods used in this study consider buildings as vulnerable which are located on steep slope (steeper than 30 degrees). Structures located on steep slope are incapable of distributing the ground distortions evenly to structural member above and in consequence the potentiality if building collapse in seismic wave. A study conducted by CDMP in 2009 states that the slope in Dhaka City Corporation (DCC)ranges from 0-15 degree which means topographic effect create negligible impact for most part of DCC. Earthquake intensity also depends on soil characteristics. The mechanical properties of the rock and soil, such as incompressibility, rigidity and density play an important role in the speed, shape and duration of earthquake waves. The CDMP study also shows that soil properties of the ward no. 34 in DSCC consists of very dense soil and soft rock which reduces the intensity of earthquake wave.

From this information the vulnerability score for Reinforced Cement Concrete (RCC) structure were calculated using the method followed by Japan International Cooperation Agency (JICA) and Comprehensive Disaster Management Program (CDMP). This method is applicable for RCC structures with a height limit of 7 stories but in most of cases damage level of taller buildings can also be calculated following the similar methods (Alam *et al*. 2008).

Performance score for each building was then calculated based on the value assigned for vulnerability parameters (Table. 3), initial score and vulnerability score. The equation was:

$$PS = \text{Initial Score} - [(\text{Vulnerability Parameter}) \times (\text{Vulnerability Score})]$$

According to Peak Ground Velocity the study area is located under Zone II (CDMP 2009 and Sadat *et al*. 2010). Finally, the damage level (vulnerability) of buildings can be classified into three categories based on their PS value as Light, Moderate and Severe/collapse. There are about 14.51% structures found have the vulnerability to severe damage to total collapse during earthquake.

Beside RCC structure there are also some Unreinforced Masonry (URM) and *kutcha* house (bamboo and other materials) found in the ward no 34 in DSCC. It is generally assumed that URM structures show poor performance during earthquake. They have limited capacity to deform once the strength of their elements has been exceeded, leading to abrupt failures. These buildings were analyzed based on their age, no. of stories and apparent building quality that counted 11% of these structures as highly vulnerable. One the other hand, *kutcha* houses mostly show less susceptibility to earthquake damage from both physical and economic perspective.

Table 3. Earthquake vulnerability assessment parameters.

Parameters	Value	
Presence of Heavy Overhang	Yes	1
	No	0
Presence of Short Column	Yes	1
	No	0
Presence of Soft Story	Yes	1
	No	0
Apparent Building Quality	Good	0
	Moderate	1
	Poor	2
Pounding between Adjacent Buildings	Yes	1
	No	0
Topographic Effect	Yes	1
	No	0

Source: Sucuoglu and Yazgan 2003, CDMP 2009 and Sadat *et al*. 2010.

All the vulnerability score for each structure was then accumulated into a single map to show their potentiality to damage during earthquake. According to the analysis, only 38.48% structures can be termed as safe in terms of earthquake damage but the rest 61.52% structures have the potentiality to damage from light to severe scale. The earthquake vulnerability is presented in Fig. 3.

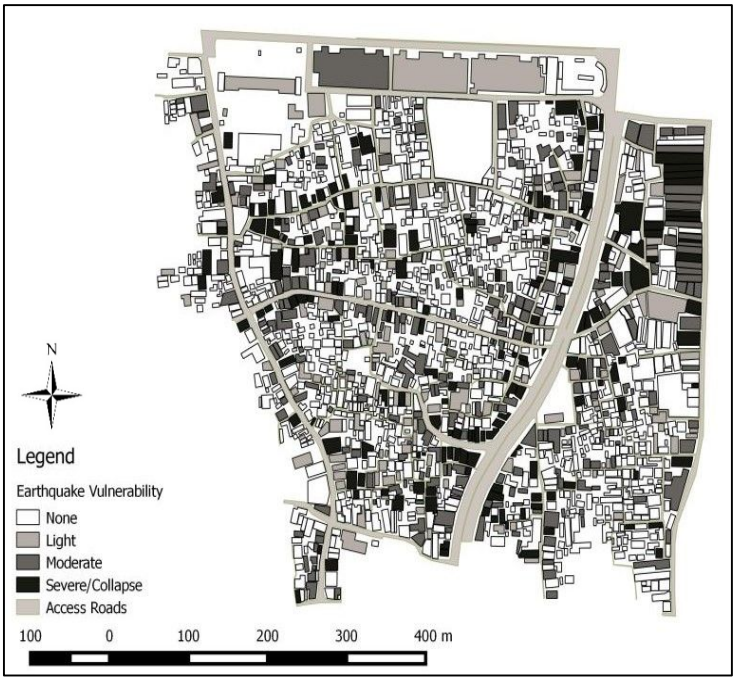

Fig. 3. Earthquake Hazard Vulnerability Assessment (Source: Field Survey 2013).

Water Logging Hazard Vulnerability: Although, ward no. 34 in DSCC is protected by flood control embankment short term water logging is prevalent here during the rainy season. In addition to improper management of pumping system, non-functionality of sluice gates and presence of hydraulic leakage with increasing rate of urbanization also impairs water logging situation in this protected area. Many water bodies were also subject to encroachment due to earth filling, deposition of city garbage and construction of building. The increasing development activities damage natural landscaping and destroy the natural drainage system. Topography is another important feature for city wide drainage function. Water moves from high to low land areas to meet the river. Topographically the area lies within 4.76 m to 6.00 m slope which is surrounded by both high and low land. Water from surrounding high land areas is discharged within this ward boundary towards river. If this water gets any obstacle on its way to drain water logging occurs. Local level water logging is also quite common in this area during rainfall (normal to heavy) when drainage system fails to remove excess rain water. Besides, nonfunctional sewerage system is also liable for the existence of waste water on the road. Some areas were even found where daily usage water overflows and always remain ankle to knee deep water on the road. The depth of water logging in ward no 34 in DSCC ranges from 1.5-2 ft. based on rainfall intensity and local topographic level. In the high land areas water stays comparatively shorter duration than the low land areas. Based on rainfall amount water logging may exist from 2 hour to 1 day. In some parts of the ward water logging is observed even for 2-3 days.

Based on the above analysis four parameters have been chosen to calculate vulnerability score for water logging as topography, average water height, presence of water logging and duration. Vulnerability score for each building was given from 0-3 based on intensity. All the structures were then categorized as severe, moderate and light considering the water logging vulnerability context (Fig. 4). Based on this analysis about one third of the study area fall under “severe” category in terms of water logging.

Table 4. Initial scores and vulnerability scores of concrete building.

Initial Score				Vulnerability Score					
No. of Stories	Zone I 60<PGV<80	Zone II 40<PGV<60	Zone III 20<PGV<40	Soft Story	Heavy Overhang	Apparent Quality	Short Column	Pounding	Topographic Effect
1.2	90	125	160	0	-5	-5	-5	0	0
3	90	125	160	-10	-10	-10	-5	-2	0
4	80	100	130	-15	-10	-10	-5	-3	-2
5	80	90	115	-15	-15	-15	-5	-3	-2
6, 7	70	80	95	-20	-15	-15	-5	-3	-2

Source: CDMP 2009.

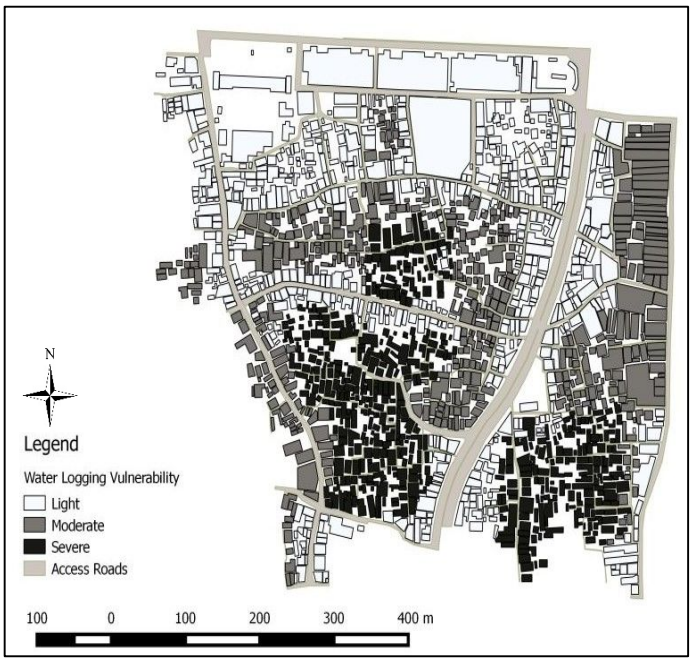

Fig. 4.Water Logging Vulnerability Assessment (Source: Field Survey 2013).

Multi Hazard Assessment: Multi hazard assessment is the way to understand the real vulnerability context of any area by considering all the potential hazards. To run this multi hazard analysis a matrix was adopted from the Federal Emergency Management Agency (FEMA) which was further modified in local context. The hazard specific vulnerability score as described in methodology section were inserted in this multi hazard index which categorized the vulnerability context into four criteria:

- Severe "A": High-risk condition with highest priority for mitigation
- Moderate 'B": Moderate-to-high-risk condition with risk addressed by mitigation
- Light "C": Risk condition is light but give consideration for further mitigation and planning
- Low "D": No risk condition with additional mitigation

Here, structures in category "A" show the highest vulnerability. Severe vulnerability to both fire and earthquake certainly influence those structures to fall under category "A". Buildings moderately vulnerable to either category but severely affected by any of the hazard i.e. fire or earthquake also fall the buildings under "A". The rest of the values were assigned based on cumulative hazard vulnerability assessment result.

According to this analysis there are about 7%, 27.41% and 64.18% structures identified as severely, moderately and lightly vulnerable respectively. The buildings with severe vulnerable are mostly used as mixed use with hazardous structure. Moreover, the earthquake risk factor like overhang building part with short columns etc. makes these structures severely vulnerable. There are also 1.41% buildings found which shows zero vulnerability to both fire and earthquake hazard.

Similar approach was applied to get multi-hazard score for earthquake, fire and water logging. The score arrived from Table 5 was accumulated with water logging vulnerability score to calculate the final multi-hazard picture. According to this analysis about 11.12% structures were identified as severe whereas about 63.53% found as moderately vulnerable. Figs. 5 and 6 illustrate the graphical and spatial pattern of vulnerable structures for fire, earthquake and water logging.

Table 5. Earthquake and fire hazard matrix.

Earthquake / Fire	Severe	Moderate	Light	None
Severe	A	A	B	B
Moderate	A	B	B	C
Light	B	B	C	C
None	B	C	C	D

Source: Modified from Federal Emergency Management Agency (FEMA) 1993.

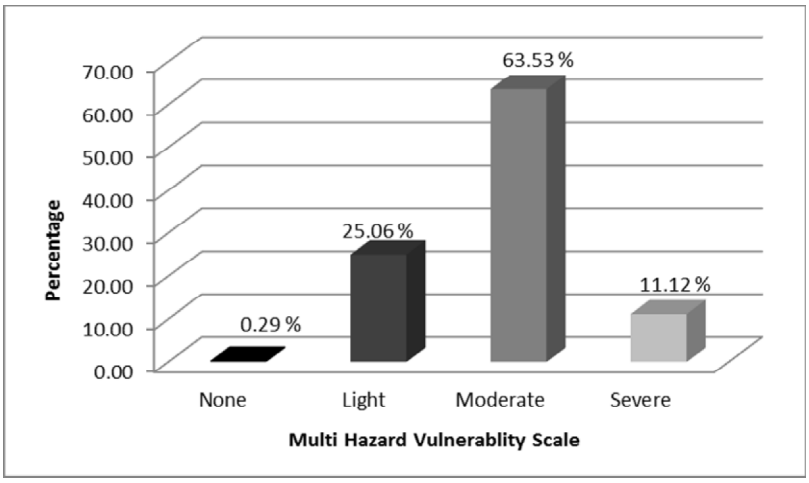

Fig. 5. Structures showing Multi Hazard Vulnerability (Source: Field Survey 2013).

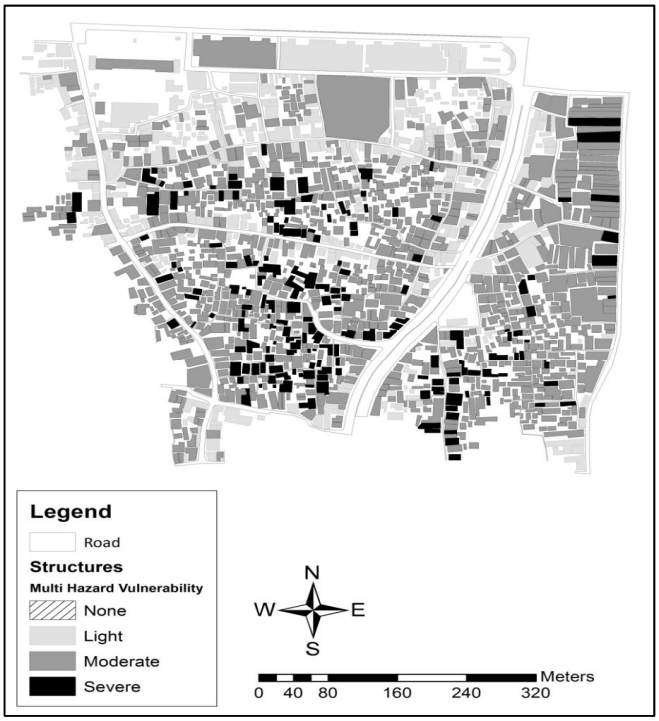

Fig.6.Multi Hazard Vulnerability Assessment (Source: Field Survey 2013).

The multi-hazard analysis performed in this study clearly states that the risks are not separated but strictly interconnected. Different threats can interfere among them and result in multi-hazard vulnerability. For example, while integrating fire and earthquake hazard are about 64.18% of the structures found as low vulnerable but the amount cut into only 25.06% while integrating water logging vulnerability in it. Water logging has changed the vulnerability context of the area. Thus, in a small area vulnerability situation may vary due to presence of several vulnerability parameters. Structures located adjacent to hazardous sources with limited access to roads were identified as vulnerable to fire. But those structures may not be vulnerable for earthquake due to nonexistence of soft story, heavy overhang and other vulnerability parameters. So, individual hazard analysis can give the vulnerability context of one hazard which incomplete as the area is susceptible to many hazards. There are many buildings located in water logged areas vulnerable to fire hazard. That means the buildings required mitigation and preparedness measure for both hazards. Single hazard mitigation will increase the susceptibility rather than improving the context.

The effective capacity of building resilience in large cities depends on a thorough knowledge of their exposure to risks. Almost each urban area, especially extended and highly populated cities, is exposed to a number of different risks. The whole set of risks

should be taken into consideration in the urban planning process. Multi hazard approach thus helps planning authorities to look into separate angle of hazard context to ensure safety to future residents. Ignoring one hazard may results into failure of entire planning system. Micro level planning is hence required in this regard to consider the localized context as well as the general hazard condition. This helps to develop a disaster resilient safe city for its inhabitants.

References

Alam, M. J., M. A. R. Khan, and A. Paul. 2008. Seismic Vulnerability Assessment of Existing Building in GIS Environment, Kanpur: IIT, India, 3-6.

BBS. 2014. Bangladesh Population and Housing Census 2011: National Volume- 3: Urban Area Report. Dhaka: Bangladesh Bureau of Statistics. Statistics and Informatics Division, Ministry of Planning, Government of the people's republic of Bangladesh, 60.

Cardona, N. C., R. Davidson, and A. C. Carlos A. Villacis. 2001. A Project to Study Urban Earthquake Risk Worldwide, International Conferences on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, March Paper 23:2-3 Retrieved from: http://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=3675&context=icrageesd

CDMP. 2009, Risk Assessment of Dhaka, Chittagong and Sylhet City Corporation Area. Dhaka: Comprehensive Disaster Management Programme, 42-56.

FEMA. 1993. Risk Assessment Approaches, Part III, Washington, D.C.: Federal Emergency Management Agency, 315.

Gencer, E. A. 2013. *The Interplay between Urban Development, Vulnerability, and Risk Management: A Case Study of the Istanbul Metropolitan Area*, Berlin, Heidelberg: Springer.

GOB. 1937. Electricity Rules, Dhaka: Government of the People's Republic of Bangladesh.

Islam, M. M. and N. Adri. 2008. Fire Hazard Management of Dhaka City: Addressing Issues Relating to Institutional Capacity and Public Perception, Jahangirnagar *Planning Review*, **6 (6)**:56-67.

Islam, N. 1998. Dhaka City: Some General Concerns. Asian Cities in the 21st Century: Contemporary Approaches to Municipal Management, **3 (6)**: 71-82. Philippines: ADB.

Khatun, H. 2003. *Dhakaiyas on the Move*, Academic Press and Publishers Ltd. Dhaka.

Marzocchi, W., M. L. Mastellone, A. Di Ruocco, P. Novelli, E. Romeo and P. Gasparini. 2009. Principles of multi-risk assessment - Interaction amongst natural and man-induced risks, Brussels: European Commission.

NZSEE. 2006. Assessment and Improvement of the Structural Performance of Buildings in Earthquakes, Wellington: New Zealand Society for Earthquake Engineering, App-35-37.

OAS. 1991. Primer on Natural Hazard Management in Integrated Regional Development Planning, Washington, D.C: Organisation of American States, x-xvi.

Roy, B. K. 2011, Fire hazard vulnerability: A case study in Dhaka city, The Daily Sun, October 8, 2011. Retrieved from: http://www.daily-sun.com/details_yes_08-10-2011_Fire-hazard-vulnerability:-A-case-study-in-Dhaka-city_366_2_28_1_0.html

Sucuoglu, H. and U. Yazgan, U. 2009. Simple Survey Procedures for Seismic Risk Assessment in Urban Building Stocks, Seismic Assessment and Rehabilitation of Existing Buildings, NATO Science Series, **IV (29)** : 97-118.

Sadat, M. R., M. S. Huq and M. A. Ansary. 2010. Seismic Vulnerability Assessment of Buildings of Dhaka City. *Journal of Civil Engineering (IEB)*, **38 (2)**:159-172.

(Revised copy received on 18-10-2017)

J. Asiat. Soc. Bangladesh, Sci. 43(2): 197-206, December 2017

POTENTIALS OF RICE STRAW, RICE HULL AND SAW DUST ON THE GROWTH AND YIELD PERFORMANCE OF RICE GROWN UNDER VARIABLE MOISTURE CONDITIONS IN SALINE SOIL

SUMA AKTER[1], MD. HARUNOR RASHID KHAN
AND MOHAMMED SADID HOSSAIN
Department of Soil, Water and Environment
University of Dhaka, Dhaka-1000, Bangladesh

Abstract

A field trial was carried out with rice (BRRI 64) grown in saline soil at Kuakata of Patuakhali District to evaluate the potential of rice straw, rice hull and saw dust each applied at the rates of 0, 4, 8 t ha^{-1} in moist and saturated conditions. Growth parameters and yield of rice were found to increase significantly ($p \leq 0.05$) with the increased rates regardless of kinds of organic treatments under both the conditions. The highest plant heights (89 cm in moist and 101 cm in saturated condition) were recorded at maturity in the treatment, which received the combination ($RH_8RS_8SD_8$) of highest rates of these 3 organic amendments. The lowest plant heights (73 cm in moist and 77 cm in saturated) were recorded in control condition ($RH_0RS_0SD_0$). The maximum numbers of tillers were observed in $RH_8RS_8SD_8$ and $RH_8RS_4SD_8$ followed by $RH_8RS_8SD_4$, $RH_8RS_4SD_4$ and $RH_4RS_8SD_8$ treatments at saturated condition. The straw dry matter and grain yields of rice were also found to vary significantly ($p \leq 0.05$) due to single application of rice hull, rice straw, saw dust and moisture conditions but their combined effects were found to be significantly better at the higher levels. The highest grain yield (6.6 t ha^{-1}) was recorded in $RH_8RS_8SD_8$ treatment followed by $RH_8RS_8SD_4$, $RH_8RS_4SD_8$, $RH_8RS_4SD_4$ and $RH_4RS_8SD_8$ at saturated condition. Growth and yield of rice were attained better at saturated condition than that of the moist soil.

Key words: Growth and yield performance of rice, Rice hull, Rice straw, Saw dust, Saline soil

Introduction

More than 30% of the cultivable land in Bangladesh is in the coastal area (SRDI 2010) which deserves much attention due to its low productivity especially for rice cultivation. Out of 2.86 million hectares of coastal and off-shore lands about 1.06 million ha of arable lands are affected by varying degrees of salinity. Farmers mostly cultivate low yielding, traditional rice varieties during wet season. Most of the land remains fallow in the dry season (January to May) because of soil salinity, lack of good quality irrigation water and Na-enrichment hampered drainage condition (Khan *et al.* 2016). Because of salinity, special environmental and hydrological situation exists that restrict the normal crop production throughout the year. Increased level of salinity negatively influences germination, plant growth and reproducibility, physiological processes, including

[1] Corresponding author: suma_nur5@yahoo.com

photosynthesis, respiration, transpiration, membrane properties, nutrient balance, enzymatic activity, and metabolic activities, cellular homeostasis and hormone regulation and leads to production of Reactive Oxygen Species (ROS) and in severe stress, it leads to plant death (Hasanuzzaman *et al*. 2012).

Observations in the recent past indicated that due to increasing degree of salinity of some areas and expansion of salt affected area as a cause of further intrusion of saline water, normal crop production becomes more restricted. In general, soil salinity is believed to be mainly responsible for low land use as well as cropping intensity in the area (Haque 2006). Increased pressure of growing population demand more food. Thus, it has become very important to explore the possibilities of increasing the potential of these saline lands for increased production of crops.Therefore, salt-affected soils must be reclaimed to maintain satisfactory levels of fertility for sustaining food production. The salinity affected coastal areas could be reclaimed by different management strategies, such as improved hydrology, application of agricultural amendments and adaptation/screen out of different salt tolerant crops. Tejada *et al*. (2006) suggested for the use of organic fertilizers for reclaiming saline and sodic soils, which may increase their fertility but this suggestion need to be assessed. Thus the present study was carried out to evaluate the effects of rice hull, rice straw and saw dust on the growth and yield performance of rice plants in coastal saline soil.

Materials and Methods

The experiment was conducted with a T. Boro rice cultivar (BRRI 64) at Musulliabad (Lata Chapli), Kalapara, Patuakhali, Bangladesh, during January to June, 2016. Physico-chemical characteristics of initial soil (Table 1) were determined following the standard methods.

Rice Hull (RH), Rice Straw (RS) and Saw Dust (SD) were used as indigenous amendments for the studied soil. The experiment was conducted following Completely Randomized block design with 3 factors, such as Rice Hull, Rice Straw and Saw Dust having 3 dosages of each with 3 replications (considered within the plot) under 2 moisture levels (moist and saturated; Fig. 1)). Total number of treatment was 27 (3 RH × 3 RS × 3 SD: for each moisture level, Table 2). Basal doses of N, P_2O_5 and K_2O were applied at the rate of 120, 60 and 80 kg ha^{-1}as Urea, TSP and MoP, respectively. The whole TSP, MoP and half of the urea were applied during preparation of land. The remaining urea was top dressed in two splits, at active tillering and panicle initiation stage.

Seedlings were collected from the local farmers. Thirty-days-old seedlings of BRRI 64 were transplanted at the rate of 3 seedlings per hill. The hill to hill and row to row distances were 18 and 22 cm, respectively. For proper establishment of the seedlings, the plots in the field were irrigated with pond water for two weeks after transplantation and then the moisture levels were controlled. The field moisture contents of 80% and > 100% were considered at the moist and saturated conditions, respectively throughout the growing period. Intercultural operations were performed as required.

Table 1. Physico-chemical properties of initial soil on oven dry basis.

Properties	Values
Particle density (g cm^{-3})	2.53
Bulk density (g cm^{-3})	1.37
Porosity (%)	45.81
Moisture content (%; Black 1965)	3.31
Textural class (Hydrometer method; Piper 1966)	Clay loam
pH (1:2.5; Jackson 1973)	6.90
EC (dS m^{-1}; Saturation extract, 1:5; Richards 1954)	3.96
Organic carbon (g kg^{-1}; Nelson and Sommers 1982)	7.80
Total Nitrogen (g kg^{-1}; Jackson 1973)	0.60
Available Nitrogen (mg kg^{-1}; 1 N KCl; Jackson 1973)	54.55
Available Phosphorus (mg kg^{-1}; Olsen *et al.* 1954)	12.58
Available Potassium (mg kg^{-1}; Pratt 1965)	25.00
Exchangeable Cations (c mol kg^{-1}; 1 N CH_3COONH_4)	
Sodium (flame photometer)	3.91
Potassium (flame photometer)	0.64
Calcium (AAS*)	1.87
Magnesium (AAS*)	3.26
Water Soluble Anions (c mol kg^{-1})	
Chloride (0.005 N $AgNO_3$; Richards 1954)	2.87
Sulphate ($BaCl_2$; Richards 1954)	1.45
Bicarbonate (0.05 N H_2SO_4; Richards 1954)	0.47
Carbonate (0.05 N H_2SO_4; Richards 1954)	ND#
Cation Exchange Capacity (c mol kg^{-1}; Black 1965)	18.67
Sodium Adsorption Ratio (Richards 1954)	7.72
Exchangeable Sodium Percentage (Richards 1954)	20.92

*AAS = Atomic Absorption Spectrophotometer, #ND = Not in detectable range.

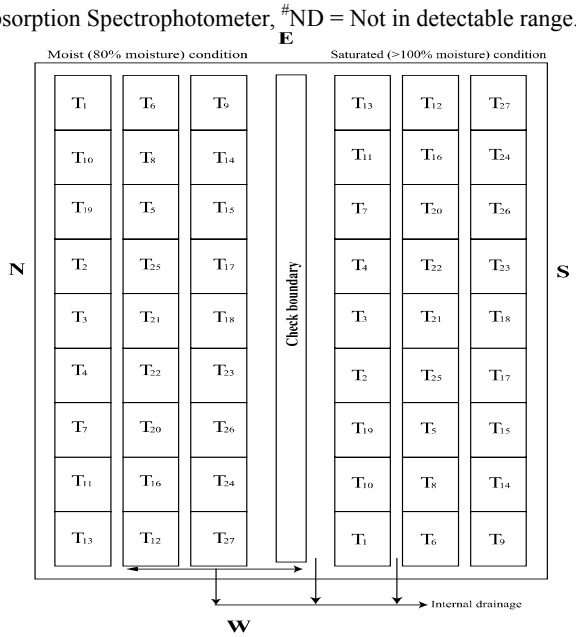

Fig. 1. Layout of the field experiment.

Table 2. Treatment combinations of the experiment.

Treatment		Rate (t ha^{-1})		
No.	Denotation	Rice Hull (RH)	Rice Straw (RS)	Saw Dust (SD)
T_1	RH_0 RS_0 SD_0	0	0	0
T_2	RH_0 RS_0 SD_4	0	0	4
T_3	RH_0 RS_0 SD_8	0	0	8
T_4	RH_0 RS_4 SD_0	0	4	0
T_5	RH_0 RS_4 SD_4	0	4	4
T_6	RH_0 RS_4 SD_8	0	4	8
T_7	RH_0 RS_8 SD_0	0	8	0
T_8	RH_0 RS_8 SD_4	0	8	4
T_9	RH_0 RS_8 SD_8	0	8	8
T_{10}	RH_4 RS_0 SD_0	4	0	0
T_{11}	RH_4 RS_0 SD_4	4	0	8
T_{12}	RH_4 RS_0 SD_8	4	0	8
T_{13}	RH_4 RS_4 SD_0	4	4	0
T_{14}	RH_4 RS_4 SD_4	4	4	4
T_{15}	RH_4 RS_4 SD_8	4	4	8
T_{16}	RH_4 RS_8 SD_0	4	8	0
T_{17}	RH_4 RS_8 SD_4	4	8	4
T_{18}	RH_4 RS_8 SD_8	4	8	8
T_{19}	RH_8 RS_0 SD_0	8	0	0
T_{20}	RH_8 RS_0 SD_4	8	0	4
T_{21}	RH_8 RS_0 SD_8	8	0	8
T_{22}	RH_8 RS_4 SD_0	8	4	0
T_{23}	RH_8 RS_4 SD_4	8	4	4
T_{24}	RH_8 RS_4 SD_8	8	4	8
T_{25}	RH_8 RS_8 SD_0	8	8	0
T_{26}	RH_8 RS_8 SD_4	8	8	4
T_{27}	RH_8 RS_8 SD_8	8	8	8

Plant height, tiller number, straw and grain yields were recorded after harvesting the crop at maturity. The significance of different treatments was assessed by Duncan's New Multiple Range Test (DMRT) and Tukey comparisons.

Results and Discussion

Plant Height and Tiller Production

Growth period and environment under which plant is grown are the important factors in the life history of rice plant. It is convenient to regard the life history of rice in terms of three growth stages: vegetative, reproductive and ripening (Yoshida 1981). The vegetative stage is characterized by tillering and gradual increase in plant height. Plant height and tiller production at different growth stages are important such as for the selection of plants for low, medium and high lands, fertilizing and other cultural practices. Moreover, the present study was made on problematic soils, where plant life cycle is sometimes irregular. Accordingly, plant height and tiller production of rice were considered for this present study.

Plant Height

Plant height increased significantly ($p \leq 0.05$) with the advent of time and with the rates of application of the indigenous organic amendments viz. rice hull, rice straw and saw dust which might be due to maintenance of favorable conditions for plant growth resulting an improvement in plant heights (Fig. 2). The individual variables such as rice hull, rice straw, saw dust and their combination produced statistically significant increase in plant height both at moist and saturated conditions. The highest heights of rice plant (89 cm in moist and 101 cm in saturated condition) were recorded in the $RH_8RS_8SD_8$ treatment, which received the highest rates of combination of these 3 amendments. The lowest plant heights (73 cm in moist and 77 cm in saturated condition) were recorded in the control condition ($RH_0RS_0SD_0$).

Kamara *et al*. (2015) reported that rice plants grown on soils treated with rice straw were significantly ($p < 0.05$) taller than those grown on soils without treatment. Incorporation of rice straw into the soil combined with cattle manure gave the maximum plant height (Parham *et al.* 2002).

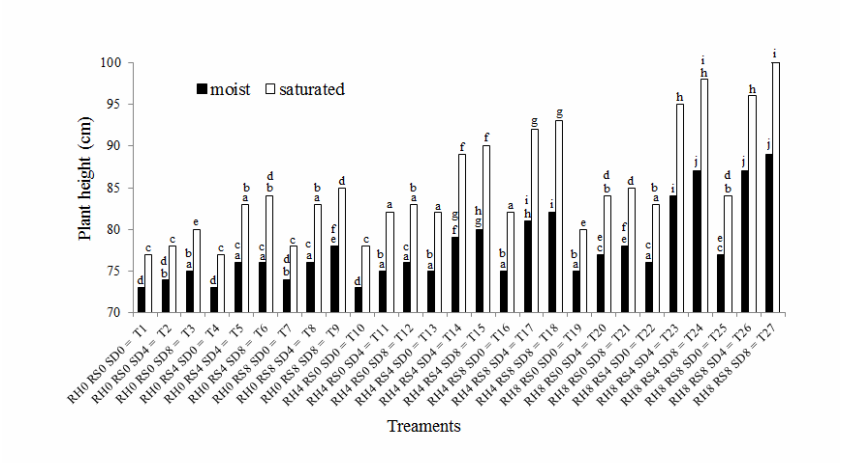

Fig. 2. Height of rice plant (BRRI 64) as influenced by the application of rice hull, rice straw, saw dust and moisture conditions.

Tiller Production: The numbers of productive tillers counted at moist and saturated conditions were found to be influenced by applied treatments (Fig. 3). The tiller production of rice was significantly ($p \leq 0.05$) higher over control in most of the treatments irrespective of the rates of rice hull, rice straw and saw dust in both moist and saturated conditions (Fig. 3). The maximum numbers of tillers were observed in $RH_8RS_8SD_8$ and $RH_8RS_4SD_8$, followed by $RH_8RS_8SD_4$, $RH_8RS_4SD_4$ and $RH_4RS_8SD_8$ treatments at saturated condition. The actual numbers of tillers were observed (24 - 33%) more than those shown at the maturity stage of rice growth (Fig. 3) and the decrement of the numbers of tillers were almost a usual phenomena of rice production under this

problematic saline soil. However, the increments of number (17 – 183%) of tillers by the application of organic amendments in the present study might be the resultant effect of addition of organic matter in turn release of nutrients to the soil.

Straw Yield: The straw dry matter yields were found to be higher at saturated condition as compared to moist condition in all treatments (Tables 3 and 4). The maximum straw yield was attained by the $RH_8RS_8SD_8$ treatment while the treatments $RH_8RS_8SD_4$, $RH_8RS_4SD_8$ and $RH_8RS_4SD_4$ were ranked second at the saturated condition of the soil. The trends of influence of the other treatments were almost similar with their higher rates and combinations. Straw yields were observed significant ($p \leq 0.05$) for different levels of rice hull, rice straw and saw dust alone and their combinations in both the soil moisture conditions. The straw yields in treatments having the lower ECe values were found to be superior to that of the higher ECe values. Rice hull, rice straw and saw dust applied together at the rate of 8 t ha^{-1} under saturated condition were found to be effective in increasing straw yield of rice. The results demonstrated that the application of rice hull, rice straw and saw dust alone and in combination were found to improve the dry matter production of straw at saturated condition through imparting favorable conditions for the growth and uptake of nutrients by rice.

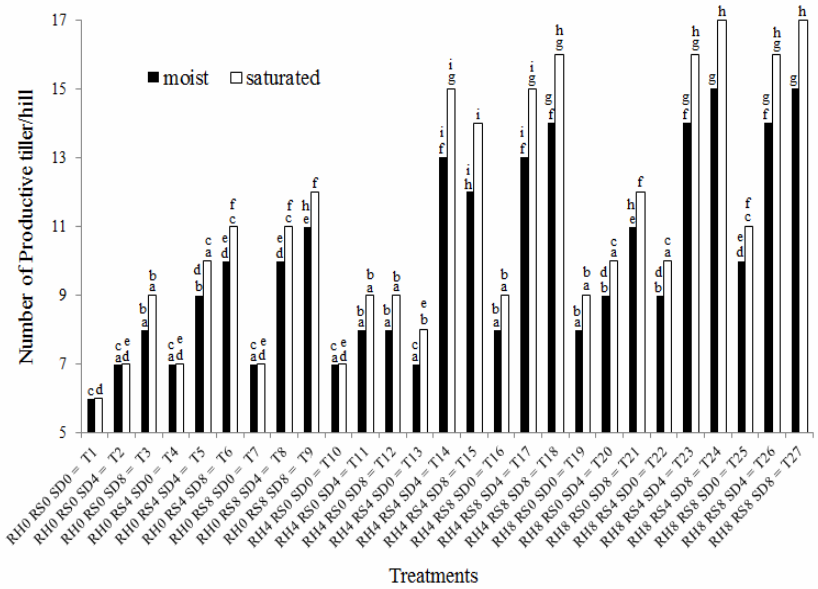

Fig. 3. Tiller production of rice (BRRI 64) as influenced by the application of rice hull, rice straw, saw dust and moisture conditions.

Table 3. Straw yield (t ha^{-1}) of rice under moist condition as influenced by the application of rice hull, rice straw and saw dust in saline soil.

RH × RS × SD		Rice Straw (RS: t ha^{-1})	Saw Dust (SD: t ha^{-1})			RH- mean	RS- mean
			0	**4**	**8**		
Rice Hull (RH: t ha^{-1})		**0**	3.6 l	3.9 kl	4.0 k		
	0	**4**	3.9 kl	4.4 ij	4.6 ghi	4.19	4.22 (0 t ha^{-1})
		8	4.1 jk	4.5 hi	4.7 fghi		
	4	**0**	3.9 kl	4.5 hi	4.4 ij	4.64	
		4	4.4 ij	4.9 efg	5.0 def		4.74 (4 t ha^{-1})
	8	**8**	4.6 ghi	5.0 def	5.1 cde	5.01	
		0	4.1 jk	4.7 fghi	4.9 efg		
		4	4.7 fghi	5.3 bcd	5.5 ab		4.88 (8 t ha^{-1})
		8	4.8 efgh	5.4 abc	5.7 a		
Saw Dust (SD)-mean			4.23	4.73	4.87		

In a column and row, means followed by a common letter are not significantly different at 5% level (Tukey comparisons).

Table 4. Straw yield (t ha^{-1}) of rice under saturated condition as influenced by the application of rice hull, rice straw and saw dust in saline soil.

RH × RS × SD		Rice Straw (RS: t ha^{-1})	Saw Dust (SD: t ha^{-1})			RH- mean	RS- mean
			0	**4**	**8**		
Rice Hull (RH: t ha^{-1})		0	3.9 l	4.2 kl	4.3 k		
	0	4	4.2 kl	4.8 j	5.1 hij	4.57	4.60 (0 t ha^{-1})
		8	4.4 k	5.0 ij	5.2 ghi		
	4	0	4.2 kl	5.0 ij	4.8 j	5.18	
		4	4.8 j	5.5 efg	5.7 def		5.28 (4 t ha^{-1})
	8	8	5.1 hij	5.7 def	5.8 cde	5.58	
		0	4.4 k	5.2 ghi	5.4 fgh		
		4	5.2 ghi	6.0 bcd	6.2 ab		5.44 (8 t ha^{-1})
		8	5.3 ghi	6.1 abc	6.4 a		
Saw Dust (SD)-mean			4.61	5.28	5.43		

In a column and row, means followed by a common letter are not significantly different at 5% level (Tukey comparisons).

Grain Yield: The analysis of variance of the data evince that the grain yields of rice significantly ($p \leq 0.05$) varied by the individual application of rice hull, rice straw, saw dust (0, 4, 8 t ha^{-1}) and moisture conditions and their combined effects were found to be more effective and significant at the higher levels of these treatments (Tables 5 and 6). The treatment means also demonstrated that the grain yield increased significantly ($p \leq 0.05$) over the control with rate of the treatments. The single effect of rice hull, rice straw and saw dust were found to be effective in increasing the grain yield over control

but their combinations were more effective under both moisture levels. Generally, the grain yield was better in saturated condition than that obtained from moist condition in all the treatments (Tables 5 and 6). The highest yield (6.6 t ha^{-1}) was recorded in $RH_8RS_8SD_8$ treatment followed by $RH_8RS_8SD_4$, $RH_8RS_4SD_8$, $RH_8RS_4SD_4$ and $RH_4RS_8SD_8$ at saturated condition. The results are partially agreed with earlier findings of Kaniz and Khan (2013) and Iqbal (2016). They reported that the growth and yield of rice grown on saline soils increased significantly with the application of rice hull, gypsum and saw dust. Kaniz and Khan also suggested that the lower dosage (5 t ha^{-1}) was effective but the higher dosage (10 t ha^{-1}) behaved negatively in improving the adverse effect of salinity and yield performance of saline sensitive rice variety.

Results suggest that the rice yields obtained from the studied saline soil increased from 3.4 to 6.6 t ha^{-1} due to the application of rice hull, rice straw and saw dust each at the rates of 4 and 8 t ha^{-1} under variable moisture conditions, which is encouraging and environmentally sound if these amendments are available locally.

Table 5. Grain yield (t ha^{-1}) of rice under moist condition as influenced by the application of rice hull, rice straw and saw dust in saline soil.

RH × RS × SD		Rice Straw (RS: t ha^{-1})	Saw Dust (SD: t ha^{-1})			RH- mean	RS- mean
			0	**4**	**8**		
Rice Hull (RH: t ha^{-1})	**0**	**0**	3.4 n	3.5 mn	3.6 lmn		
		4	3.5 mn	3.9 ijkl	4.1 ghij	3.77	3.82 (0 t ha^{-1})
		8	3.7 klmn	4.0 hijk	4.2 fghi		
	4	**0**	3.6 lmn	4.0 hijk	3.9 ijkl	4.22	
		4	3.9 ijkl	4.5 def	4.6 de		4.34 (4 t ha^{-1})
	8	**8**	4.1 ghij	4.6 de	4.8 cd	4.67	
		0	3.8 jklm	4.2 fghi	4.4 efg		
		4	4.2 fghi	5.1 bc	5.3 ab		4.49 (8 t ha^{-1})
		8	4.3 efgh	5.2 ab	5.5 a		
Saw Dust (SD)-mean			3.83	4.33	4.49		

In a column and row, means followed by a common letter are not significantly different at 5% level (Tukey comparisons).

Table 6. Grain yield (t ha^{-1}) of rice under saturated condition as influenced by the application of rice hull, rice straw and saw dust in saline soil.

RH × RS × SD		Rice Straw (RS: t ha^{-1})	Saw Dust (SD: t ha^{-1})			RH- mean	RS- mean
			0	**4**	**8**		
Rice Hull (RH: t ha^{-1})	**0**	**0**	3.6 j	3.7 ij	3.8 ij		
		4	3.7 ij	4.2 fgh	4.4 ef	4.01	4.08 (0 t ha^{-1})
		8	3.9 hij	4.3 efg	4.5 def		
	4	**0**	3.8 ij	4.3 efg	4.2 fgh	4.78	
		4	4.2 fgh	5.4 c	5.5 c		4.92 (4 t ha^{-1})
	8	**8**	4.4 ef	5.5 c	5.7 c	5.29	
		0	4.0 ghi	4.5 def	4.8 d		
		4	4.5 def	6.1 b	6.3 ab		5.08 (8 t ha^{-1})
		8	4.6 de	6.2 b	6.6 a		
Saw Dust (SD)-mean			4.08	4.91	5.09		

In a column and row, means followed by a common letter are not significantly different at 5% level (Tukey comparisons).

Regardless of rates of these organic amendments, rice hull, rice straw and saw dust exerted almost similar and better growth-yield performances of rice under saturated soil condition than those of the moist condition of the saline soil, which suggests that soil water is an important factor to manage these organic amendments more effectively in saline soil. However, further research is still needed to work out the dosages of these organic amendments for the production of rice under saline environments. The potential of the amending materials for salt tolerance and their adaption by farmers under variable climates, crop response and socio-economic considerations should also be kept in mind for further practices and recommendation.

Acknowledgements

The study was carried out under the project entitled 'Multidisciplinary Approaches for Green Transformation and Development of Agriculture in Salt-affected Coastal Soils Under Changing Climatic Conditions' funded by the Ministry of Science and Technology, Government of the People's Republic of Bangladesh. We are also grateful to the Ministry of Science and Technology for providing NST fellowships to Suma Akter and Mohammed Sadid Hossain.

References

Black, C.A. (ed.) 1965. *Methods of soil analysis, Part 2*, Series 9, pp. 894-1372, Am Soc. Agron. Inst. Publ., Madison, WI.

Haque, S.A. 2006. Salinity problems and crop production in coastal regions of Bangladesh. *Pak. J. Bot*. **38 (5):** 1359–1365.

Hasanuzzaman, M., M.A. Hossain, J.A. Teixeira da Silva and M. Fujita. 2012. Plant responses and tolerance to abiotic oxidative stress: antioxidant defense is a key factor in crop stress and its management: perspectives and strategies, V. Bandi, A.K. Shanker, C. Shanker and M. Mandapaka, Springer, Berlin, Germany, Eds. 261-316.

Iqbal, T. 2016. Rice straw amendment ameliorates harmful effect of salinity and increases nitrogen availability in a saline paddy soil. *Journal of the Saudi Society of Agricultural Sciences* (In Press). http://dx.doi.org/10.1016/j.jssas. 2016.11.002

Jackson, M.L. 1973. *Soil Chemical Analysis*, Prentice Hall of India Pvt. Ltd., New Delhi. 36-196.

Kamara, A., H.S. Kamara and M.S. Kamara. 2015. Effects of Rice Straw Biochar on Soil Quality and the Early Growth and Biomass Yield of Two Rice Varieties. *Agricultural Sciences.* **6**: 798-806.

Kaniz, F. and H.R. Khan. 2013. Reclamation of saline soil using gypsum, rice hull and sawdust in relation to rice production. *J Adv Sci Res*, **4(3):** 1-5.

Khan, H.R., S.M. Kabir and M.M.A. Bhuiyan. 2016. Effects of selected treatments and techniques for the reclamation and improvement of Cheringa acid sulfate soil under rice production in the coastal plain of Cox's Bazar. *J. Asiat. Soc. Bangladesh, Sci*. **42 (1):** 29-40.

Nelson, D.W. and L.E. Sommers. 1982. Total carbon, organic carbon and organic matter. In *Methods of Soil Analysis, part 2*. Agron. Series 9. Page A.L. (ed.). pp. 539-579, Am. Soc. Agron., Publ. Madison, WI, USA.

Olsen, S.R., C.V. Cale, F.S. Watanabe and L.A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *USDA Circ*., 939.

Parham, J.A., S.P. Deng, W.R. Roun and G.V. Johnson. 2002. Long-term cattle manure application in soil. *Bio Fertile Soils*. **35**: 328-337.

Piper, C.S. 1966. *Soil and Plant Analysis*, pp. 77. Hano Publ. Bombay, India.

Pratt P.F. 1965. *Methods of Soil Analysis* (Black C.A. Ed.) pp.1022. Am. Soc. Agron. Madison, Wisconsin, USA.

Richards, L.A. (ed.). 1954. *Diagnosis and improvement of saline and alkali soils*. In *USDA Handbook No. 60*. pp. 84-156. US Govt. Print. Office, Washington, USA.

SRDI. 2010. Saline soils of Bangladesh. SRMAF project. Ministry of Agriculture, Govt. of the people's republic of Bangladesh, Farmgate, Dhaka.

Tejada, M., C. Garcia, J.L. Gonzalez and M.T. Hernandez. 2006. Use of organic amendment as a strategy for saline soil remediation: Influence on the physical, chemical and biological properties of soil. *Soil Biol. Biochem*. **38**: 1413–1421.

(Revised copy received on 10-10-2017)

J. Asiat. Soc. Bangladesh, Sci. 43(2): 207-222, December 2017

CONTAMINATION OF SOIL AND PLANT BY THE HAZARIBAGH TANNERY INDUSTRIES

M.N. MONDOL[1], A. ASIA, A.S. CHAMON AND S.M.A. FAIZ
Department of Soil, Water and Environment,
University of Dhaka, Dhaka-1000, Bangladesh

Abstract

An investigation was made at Hazaribagh Tannery area, comprising about 145 industries in Dhaka Metropolitan area. The analyses of soil and plant samples showed that heavy metals contribute significantly towards environmental contamssination resulting from industrial activities. Concentration of heavy metals (Cr, Zn, Pb, Cd, Mn, Fe and Ni) in soil and plant samples cross the MAC (Maximum allowable concentration) in both wet and dry season. In case of soil sample the highest concentration of Cr (172792 ppm) was found at main disposal point. Chromium, Zn, Pb, Cd, Mn, Fe and Ni concentrations at Hazaribagh plant samples respectively ranged from 171-1348, 247-777, 45-96, 1.66-2.17, 72-231, 354-787, and 18-38 ppm respectively in dry season and 75-1142, 209-691, 29-84, 1.02-2.00, 66-124, 331-664, 11-37 ppm respectively in wet season. Concentration went down gradually with increasing distance from the main disposal point (spot 1). But again high concentration (150708 ppm of Cr) was noted in spot 6. Similar results were found for plant samples. High concentrations of heavy metals were found in plant samples which consequently affect food chain, which may be a major environmental concern.

Key words: Chromium, Copper, Lead, Cadmium, Zinc, Tannery wastes, Effluents, Heavy metal

Introduction

Soil and environment are under tremendous pressure due to industrial expansion and increased use of agricultural chemicals. Very few are aware of this globally important issue. The third world countries, especially Bangladesh are now in a vulnerable position. Bangladesh has now more than 30,000 industrial units (DOE 1991). With the advent of industrialization, wastes and effluent are being discharged into the natural ecosystems without treatment, creating pollution especially of heavy metals (Cr, Zn, Pb, Cd, Fe, Mn, Ni etc.).

Tannery industries of Hazaribagh situated in a heavily populated residential area discharge some 21,600 square meters of liquid wastes and 150 metric tons of solid waste everyday. These harmful wastes, including chromium, lead, sulphur, ammonium, salt and other materials, are severely polluting the capital city and the river Buriganga (Elahi *et al.* 2010). About 59% of the total wastage comes from processing of hides and skin and accumulates in the swamp-sludge. A recent research revealed that out of 270 tanneries in the country, except for two BATA and Dhaka Leather Complex-none of the tanneries has a treatment plant as required by the law (ImmamulHuq 1998).

[1]Corresponding author: mondol-bangladesh@hotmail.com

Rice and wheat which were grown in a pot experiment in soils from the tannery area showed delayed maturity and stunting growth while rice showed late flowering and maturity with dark green colour (Chamon *et al.* 2005). In another experiment it was observed that application of tannery effluents to soils of differing textures resulted in reduction of rice yield and the adverse effect was more pronounced in light soils than in heavy soils (Elahi *et al.* 2010). The effluent was also found to negatively affect performance (Elahi *et al.* 2010). Similar results were also reported by Chamon *et al.* (2005). Reduction of rice yield production (43.6%) due to heavy metal toxicity with hazaribagh soil was observed before by Chamon *et al.* (2005). Extreme concentration of Cr (27,000 ppm) around the vicinity and 1335 ppm Cr in 4 km down from the main disposal point were also reported by Nuruzzaman *et al.* (1995). Heavy matals concentration at hazaribagh area increased day by day. According to Ullah *et al.* (1999) at hazaribagh soil, Cr concentration increased to 25014 ppm.

Heavy metals, even in trace amounts, destroy enzymes and interfere with or inactivate enzymes of living cells (Rahman 1992) and hence their discharge into the environment must be carefully controlled and minimized.

Tannery industry is one of the most important and largest industrial businesses in Bangladesh. The 50 years old tannery complex comprising about 194 units are discharging their solid wastes and effluents to the channels, farmer's fields, in low lying areas, along road sides and water bodies without treatment and thereby causing environmental pollution especially due to heavy metals and organic toxins. The specific objectives of the research are to study the effects of wastes and effluents on the intensity of pollution to the soils by the heavy metals and to investigate the concentration of heavy metals in the plant samples causing contamination of the food chain.

Materials and Methods

Location of Hazaribagh tannery area: The Hazaribagh tannery complex situated in Dhaka municipality area (WSW) of the city are located inside the greater Dhaka flood protection embankment. The embankment was built in the year 1989 (Chowdhury *et al.* 1996). There are about 145 tannery factories in Hazaribagh residential area. Of the 270 tannery units, 90% are located on 25 hectares of land in Hazaribagh. Liquid waste makes its way on the other side of the embankment round the clock. This liquid waste ultimately goes into the water of the Buriganga river and causes immense harm to the fish and other aquatic organisms. Toxic materials in liquid waste seep into the surrounding cropland and underground water levels. Eventually, the tannery waste poisons the soil, water, plant and air round the clock. Tannery wastes also poison the health, houses and utensils of those situated around (Iwegbue *et al*. 2006).

Soils in Hazaribagh Area: The soil series around Hazaribagh belonging to Khaler Char (Soil Survey Staff 1975) remains seasonally flooded, up to 120-150 cm deep for more

than 6 months and they are poorly to very poorly drained soils, developed in mainly medium textured Brahmaputra alluvium in permanently wet channels or depression on the old and young Brahmaputra, Meghna and Jamuna floodplains. Their profiles show little sign of development. General soil type is non-calcarious alluvium and Fluvaquent. The area inside the embankment is just organic wastes, on Jamuna alluvium, permanently wet by the effluents of the tannery factories.

Sampling: A total of 6 sampling points was chosen based on assumption of pollution intensity and types of samples. Spots are located inside and outside the embankment respectively. Spot 1 is considered the main disposal point and the increasing numbers of the spots indicate increasing distance from the main point. Soil and existing plant samples (with 3 replications) were collected twice (wet and dry seasons) on the basis of the local environmental conditions. The sampling spots were kept fixed throughout the whole sampling periods. Contaminated soil samples (with 3 replications) were collected from 0-15 cm depths of a profile with the help of spade. Out of six, 3 soil samples were collected from inside the embankment and 3 soil samples were collected outside of the embankment. The sampling points were geo referenced with GPS (Geographical Positioning System) and marked on the map. GPS locations of sampling point are presented in Table 1.

Table 1. GPS location of sampling points (both in wet and dry seasons).

No of Sampling Site	Latitudes	Longitude	Soil	Plant
1	$23^0$44.013'N	$90^0$21.807'E	√	×
2	$23^0$41.156'N	$90^0$21742'E	√	√
3	$23^0$44.552'N	$90^0$21.604' E	√	√
4	$23^0$44.673'N	$90^0$21.549' E	√	×
5	$23^0$44.600'N	$90^0$21.279' E	√	√
6	$23^0$44.501'N	$90^0$21.109' E	√	√

Soil samples collection and preservation: The soil samples collected were air dried, ground and screened to pass through 2 mm sieve and then mixed thoroughly to make it a composite sample. Dry root, grasses and other substances were discarded from the sample. Each soil sample was further ground and screened to pass through 1.0 mm and 2.0 mm sieve and was used for physical and chemical analyses.

Plant Samples collection and preservation: At main disposal point i.e. sampling point 1, all heavy metals concentration in soil was so high that no plants sample was found on that spot. The plants samples collected from other different spots are presented in Table 2.

Table 2. List of collected plant samples.

Spot No	Type of plants samples	Scientific Name
Spot 2	Grass	*Cynodon dactylon*
Spot 3	Kalmi	*Ipomoea aquatica*
Spot 4	Kalmi	*Ipomoea aquatica*
Spot 5	Grass	*Cynodon dactylon*
Spot 6	Water hyacinth	*Eichhornia crassipes*

Plant samples were collected fresh from the polluted area in required amounts, wrapped in polyethylene bags and transported to laboratory and preserved at $+4^0$C for processing on the next day. All plant samples were air dried and placed in oven for drying at 70^0C and then ground to powder for passing through a 2-mm sieve for chemical analysis. All plant samples were kept in plastic containers for chemical analyses.

Determination of physical soil properties

Soil Texture: The particle size distribution of the soils was measured by the hydrometer method (ÖNORM 1991). The textural class was determined from the Marshalls triangular co-ordinates as described by the United States Department of Agriculture (USDA 1975).

Moisture content of soil: The percent of moisture content of the soil was determined by known amount of soil in an electric oven at 105^0C for 25 hours until constant weight was obtained and moisture percentage was calculated from the sample as described by Black (1965).

Determination of chemical and physicochemical properties of Soil

Soil pH: The pH of the soil was measured electrochemically using a corning glass electrode pH meter as suggested by Jackson and Alloways (1962). The ratio of soil to water was 1:2.5.

Electrical conductivity: The electrical conductivity of the soil was measured at a soil: water ratio of 1:2 by an EC meter.

Organic Carbon and organic matter: Organic carbon was determined by wet oxidation method of Walkley and Black (1934) as describe by Piper (1950) and Jackson and Alloways (1962). The organic matter content of the soils was determined by multiplying the percentage of organic carbon with the conventional “Van-Bemmelen’s Factor” of 1.72 (Piper 1950).

Available and total Nitrogen: Available and total nitrogen of the soil were determined by “Micro Kjeldhal”s distillation method as described by Black (1965).

Total Phosphorus, Potassium, Calcium, Magnesium and Sulfur: The total P, K, Ca and Mg were extracted by digesting the soil with aqua regia (Vdlufa 1975). The total phosphorous content of the soil was determined colorimetrically at 470 nm using a spectrophotometer (UV-1200) after developing the yellow colour with vanadomolybdate as described by Jackson and Alloways (1962). Total Ca and Mg were measured titrimetrimetrically by EDTA compleximetry method (Jackson and Alloways 1962). Total and exchangeable Na and K were measured by flame photometer.

Total heavy metals in soil and plant samples

Digestion of soil samples with aqua regia (HCl: HNO_3): Soil samples were digested with $HCl+HNO_3$ (3:1) mixture under closed system (Blum *et al.* 1996). Aqua regia decomposes nearly almost all complex forming soil particles (clay minerals, organic substances, oxides, etc.) through which most of the ions go into solution and can be measured quantitatively.

Digestion of plant samples with HNO_3-$HClO_4$: 0.2g of finely ground plant sample was weighed and digested with 20 ml conc. HNO_3 and 10 ml conc. $HClO_4$ (Blum *et al.* 1996).

Measurements of Total heavy metals: All the trace elements were measured in the extracts with the help of an Atomic Absorption Spectrophotometer (AAS), model no AA421.

Results and Discussion

Physical, Chemical and Physicochemical properties of soils

Moisture content: Soil characteristics of Hazaribagh tannery area are presented in Table 3. The moisture content (%) of the soil at various sampling points ranged from 18 to 28 and 22 to 36% in dry season and wet season, respectively (Table 3).

pH: Soil pH did not vary appreciably between sampling points and ranged from 7.06 to 8.32 and 6.95 to 8.47 in dry and wet seasons, respectively (Table 3). Nuruzzaman *et al.* (1998) and Immamul Huq (1998) reported that pH of the top soil at Hazaribagh tannery area were 7.3 and 7.2. A wide range of pH from 7.2 to 12.0 and 7.3 to 9.9 was observed by Nuruzzaman *et al.* (1998) in tannery effluents and waste water, respectively,which did not affect soil pH (7.3). This might be due to buffering capacity of these soils containing high amounts of organic matter. Various tanning and coloring materials are mainly responsible for wide range of pH variation.

Particle size: The soil of Hazaribagh belongs to Khaler Char soil series and there was no noticeable difference in particle size fraction as well as sand, silt and clay percentage between the wet and dry season soil samples (Table 3).

Eh: Eh values of the soil samples ranged from -233 to -350 and -274 to -350 (mV) in dry and wet seasons, respectively (Table 3). Eh values with minus sign at different spots

indicate highly reduced condition and under reduced condition almost all heavy metal remain available to aquatic flora and fauna.

Organic matter: The organic matter content (%) in various sampling points was found to range from 4.9 to 12.6 and 3.8 to 16.2, in dry season and wet season, respectively (Table 3). In dry season maximum accumulation was observed at sampling point 1 (12.6 %) and gradually decreasing values were observed from source point 1 to downstream and outside the embankment. Same findings were also observed in wet season where the highest value of organic matter was observed at the source point i.e at the sampling point 1 (16.2%). Nuruzzaman *et al.* (1998) reported a value of organic matter (%) of 10.3% at source point. Deposition and decomposition of huge quantities of tannery effluents and solid wastes are mainly responsible for the organic matter content of the soil.

EC (Electrical Conductivity): Higher EC means higher amounts of soluble Na, Caand Mg. EC greater than 4 dS/m is harmful for plant growth (Ponnamperuma 1985). The EC (dS/m) in various sampling point ranged from 3.5 to 5.9 and 3.7 to 7.1 dS/m in dry season and wet season,respectively (Table 3). Higher values of EC at Hazaribagh tannery area were also reported before (Ullal *et al.* 1999 and Elahi *et al.* 2010).

Table 3. Physical, Chemical and physicochemical properties of soils.

Dry season									
Spot No	% Moisture	pH	% sand	% silt	% clay	Eh (mV)	OM%	EC (dS/m)	CEC (Meq/100g)
1	19.2	8.04	35.3	46	18.7	-333	12.6	5.9	38.2
2	25.12	7.70	31.6	45.8	22.6	-320	10.8	4.3	31.9
3	22.5	8.32	40	42.9	17.1	-338	10.1	4.5	29.6
4	18.12	7.72	36.9	42.6	20.5	-350	9.63	4.8	29.9
5	27.5	7.21	30.6	49.8	19.6	-235	6.9	3.9	20.6
6	24.42	7.06	40.5	42.8	16.7	-233	4.9	3.5	20.3
Wet season									
Spot No	% Moisture	pH	% sand	% silt	% clay	Eh (mV)	OM%	EC (dS/m)	CEC (Meq/100g)
1	32.2	7.23	35	46.9	18.1	-300	16.2	6.2	32.3
2	35.12	8.47	31.3	45.7	23	-350	11.3	6.8	34.4
3	36.2	7.56	40.9	42.9	16.2	-348	11.2	7.1	30.5
4	28.9	7.87	32.2	47.3	20.5	-348	9.1	4.2	29.1
5	29.6	6.95	30.6	39.8	29.6	-274	6.25	3.7	22.3
6	21.6	7.25	40.5	44.5	15	-296	3.8	4.2	26.7

CEC (cation exchange capacity): CEC (Meq/100g of the soil) at various sampling points of Hazaribagh tannery area were found to range from 20.3 to 38.2 and 22.3 to 34.5 (Meq/100g) for dry season and wet season in soil respectively (Table 3). The high CEC was related to their high organic matter content as reported by Nuruzzanman *et al.* (1995).

Total N and Available N: High concentrations of total N as well as available N were observed in the surface soil (0 to 15 cm) at Hazaribagh tannery area in both wet and dry season (Table 4). Tannery wastes increased the total N concentration of surface soils (Nuruzzanman *et al.* 1995 and Chamon *et al.* 2005*)*.The higher accumulation was observed in dry season (Table 4) (January) and lower in wet season (August).

Table 4. Physical, Chemical and physicochemical properties of soils.

Dry season											
Spot No	Total N	Available N	Total P	Available P	Total K	Available K	Total S	Ca	Mg	K	Na
								Exchangeable			
					ppm						
1	2478	960	3690	6.9	1854	148	1587	6.8	2.8	0.4	40.9
2	2158	821	3244	5.8	1485	125	1481	6.3	2.3	0.2	35
3	1965	185	2963	7.2	1250	98	1125	5.1	1.8	0.3	32.2
4	1258	89	2717	7.6	1145	89	1025	5.6	1.2	0.4	31.3
5	1325	93	2561	5.2	1006	75	658	6.4	1.9	0.4	30.6
6	1357	96	1583	2.4	654	28	745	7.2	3.6	0.5	40.5
Wet season											
Spot No	Total N	Available N	Total P	Available P	Total K	Available K	Total S	Ca	Mg	K	Na
								Exchangeable			
					ppm						
1	2145	652	3602	6.1	1569	245	1365	5.2	2.9	0.3	26.2
2	2123	478	3230	5.5	1405	124	1145	5.7	2.1	0.6	21.5
3	1658	143	2978	6.3	1236	87	1258	5.1	1.9	0.2	12.3
4	1332	92	2689	7.2	1128	98	1198	5.8	2.1	0.2	3.2
5	1258	84	2798	4.9	984	114	695	6.8	2.8	0.6	1.3
6	1378	92	1545	3.6	965	16	845	6.3	2.5	0.1	5.3

Total P and Available P: High concentrations of total P and available P were observed in the soil at Hazaribagh tannery area in both dry and wet seasons. This observed higher concentration might be due to use of higher amounts of various phosphate salts, which are used in various steps in tanning process. Compared to dry season, a lower value of total P and available P was observed in wet season ranging from 1545 to 2978 ppm and 2.4 to 7.2 ppm for total P and available P, respectively (Table 4).

Total K and Available K: The concentrations of total K at various sampling points of Hazaribagh tannery area ranged from 654 to 1854 ppm and 965 to 1569 ppm for dry and wet seasons in soil, respectively (Table 4).

Total S: The concentrations of total S in soil at various sampling points of study area were found to range from 658 to 1587 ppm and 695 to 1365 ppm in dry and wet seasons, respectively (Table 4). Higher value of total S (1587 ppm) was observed at sampling point 1 which gradually decreased with increasing distance and the lowest value (654 ppm) of total S was observed at sampling point 6. Similar results were observed in case

of wet season. Observation of lower value of total S in wet season might be due to dilution by rain water.

Exchangeable Na, K, Ca and Mg: Higher amounts of exchangeable Na, K, Ca and Mg in soil were recorded at different sampling points at Hazaribagh tannery area (Table 4). The high concentration of EC in different spots within the embankment were attribute to the increase in soluble salts particularly Na, K, Ca and Mg from the tannery effluent, values exceeding 4dS/m which is the harmful limit for rice seedling establishment (Nuruzzanman *et al.* 1995).

Heavy metals in Soil at Hazaribagh tannery area

Chromium in soil in dry and wet seasons: Chromium concentration at Hazaribagh sampling area ranged from 42792 to 172792 and 26654 to 148446 ppm in dry and wet season, respectively (Table 5). Highest Cr concentration was observed in main disposal point i.e. at spot 1 and decreasing value was observed with increasing distance from the discharge point. Significant differences were found among different sampling spots.

High Cr concentration (150708 ppm) observed at spot 6 was significantly different from other spots except spot 1, during dry season. Similar results were also observed in wet season (Table 5).Ullah *et al*. (1999) reported 25014 ppm Cr concentration at Hazaribagh area. Previously similar findings were also reported at Hazaribagh area (Chamon *et al.* 2005 and Elahi *et al*. 2010). Chromium concentration of 59333 ppm in soil was reported by Elahi *et al*. (2010). Relatively lower value of Cr was observed at the same sampling point in wet season. This might be due to dilution of Cr in soil by rain water in wet season. High Cr concentration may occur due to use of higher amount chromium sulphate ($[Cr\ (H_2O)_6]_2(SO_4)_3$), regarded as one of the most efficient and effective tanning agent, during liming, pickling and curing stage.

Cr concentration at 6 sampling points (both in dry and wet season) cross the MAC (Maximum allowable concentration) for soil (100 mg/kg) (Kloke 1980). It is evident that very high level of Cr (Table 5) along with other heavy metals were found in spot 1 which serves as a settling basin and gradually concentration went down with increasing distance of spots from spot 1. But again high concentration was noted in spot 6 (Table 5). This spot may be previously contaminated before 1989, when there was no embankment to protect this area from the tannery waste and effluents. The result indicates that the soil is extremely polluted with Cr, even outside the embankment (Nuruzzanman *et al*. 1998).

As stated earlier, the tannery discharges the effluents and wastes into the river system. Consequently, there is a large area of sludge alongside the flood protection embankment and the liquid wastes are dumped into the river through a flood control regulator-cum-sluice near Hazaribagh. During monsoon months, the flood protection embankment

protect Dhaka from heavy flooding while making it difficult to flash out the waste water, thereby creating a great environmental hazards in the neighborhood of the tanneries. On the other hand, during the dry season the waste water is flushed out into the river, causing pollution of the river water (spot 6) and ultimately affecting the aquatic flora and fauna. Likewise the dumping of the solid wastes is seriously affecting the soil and plants, besides vitiating the air, ground water and human health (Immamul Huq 1998).

Zinc (Zn) concentration in soil indry and wet seasons: Total zinc concentration at Hazaribagh sampling area ranged from 1000 to 1950 ppm and 1264 to 1896 ppm in dry and wet seasons respectively (Table 5). Highest Zn concentration was observed in main disposal point i.e. at spot 1 and decreasing value were observed with increasing distance from the discharge point. Ullah *et al.* (1999) reported 365 ppm of Zn concentration at Hazaribagh area soil. Similar findings (290 ppm) were also reported by Nuruzzaman *et al.* (1998). Elahi *et al.* (2010) found 3000 ppm Zn concentration at Hazaribagh area bulk soil (Table 5). Zn concentration at 6 sampling points (both dry and wet season) cross the MAC (Maximum allowable concentration) for soil (300 mg/kg) (Kloke 1980).

Lead (Pb) in soil in dry and wet seasons: Lead concentration at Hazaribagh sampling area was found to range from 80.5 to 157 and 24.17 to 144.57 ppm in dry and wet seasons, respectively (Table. 5). Highest Pb concentration was observed in main disposal point i.e. at spot 1 and decreasing value was observed with increasing distance. Significant differences were found among different sampling spots. 131.0 ppm of Pb concentrationwas observed at spot 6 outside of the embankment, which was significantly different from other spots except spot 1 and 2, during dry season. The value was different in case of wet season. Significant differences were observed among sampling point (Table 5). The tests of significance of differences at of different sampling points were calculated by DMRT at 5% level. 44.2 and 68.1 ppm of Pb concentration was reported by Ullah *et al.* (1999) and Nuruzzanman *et al.* (1998), respectively.

Relatively higher Pb concentrations were found at spot 6 in dry and wet seasons (131.0 and 114.57 ppm), respectively. That spot may be previously contaminated before 1989 when there was no embankment to protect this area from tannery waste or huge amounts of waste water and effluents are now continuously being added from other different industries (Ullah *et al.* 1999).

Lead concentration at 6 sampling points (both dry and wet seasons) crossed the MAC for soil (100 mg/kg) (Kloke 1980).

Table 5. Chromium (Cr), Zinc (Zn) and Lead (Pb) concentration (ppm) in soil at various sampling points of Hazaribagh area in dry and wet seasons.

Spot No	Cr (ppm)		Zn (ppm)		Pb (ppm)	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
Spot 1	172792 a	148446 a	1950 a	1896 a	157 a	145 a
Spot 2	71542 b	71238 b	1878 a	1765 a	130 ab	142 a
Spot 3	87375 b	52488bc	1778 b	1065 b	104 b	43 b
Spot 4	42792 b	26654 d	1780 b	299 b	81 c	32 b
Spot 5	59875 b	40821 cd	1586 b	200 c	75 c	24 b
Spot 6	150708 a	56238 bc	1264 c	1150 b	131 ab	115 a
Mean	97514	63411	1706	1062	113	83

Means followed by same letter in a column do not differ significantly from each other at 5% level by DMRT.

Cadmium (Cd) in soil in dry and wet seasons: Cadmium concentration at Hazaribagh sampling area ranged from 2.33 to 1.5 ppm and 0.75 to 2.10 ppm in dry and wet season, respectively (Table 6). The highest Cd concentration was observed in main disposal point i.e. at spot 1 and decreasing value was observed with increasing distance from discharge point. Significant differences were found among different sampling spots except spot no 1, 3 and 4. 1.50 ppm of Cd concentration was observed at spot 6 which were not significantly different from other spots (Spot no 3 and 4) during dry season. The value was different in case of wet season. Significant difference was observed among sampling points (Table 6). The tests of significance of different sampling point were calculated by DMRT at 5% level.

Lower value of Cd concentration observed in wet season might be due to dilution of Cd of soil by rain water. Cadmium concentration may be higher due to use of cadmium sulphate during curing and finishing stage. Huge amount of cadmium sulphate and cadmium phosphate are used to polish the hide and skin. Cadmium concentration at 6 sampling points (both in dry and wet season) did not cross the MAC for soil (3.00 mg/kg) (Kloke1980).

Manganese (Mn) in soil in dry and wet seasons: Manganese concentration at Hazaribagh sampling area ranged from 333 to 733 and 183 to 601ppm in dry and wet seasons, respectively (Table 6). The highest Mn concentration was observed in main disposal point i.e. at spot 1 and decreasing value was observed with increasing distance. Significant differences were found among different sampling spots. Manganese (Mn) concentration of 561 ppm was observed at spot 6 which was significantly, different from other spots, during dry season. The value was different in case of wet season. No

significant differences were observed among sampling point 1, 2, 3, 6 and 4, 5 (Table 6). The tests of significance of different sampling point were calculated by DMRT at 5% level. Ullah *et al*. (1999) had reported 263 ppm Mn concentration at Hazaribagh area and 425 ppm of Mn concentration in soil was reported by Nuruzzaman *et al.*(1998). Manganese concentration at 6 sampling points (both in dry and wet season) did not cross the MAC for soil (1000 mg/Kg) (Kloke 1980).

Iron (Fe) in soil in dry and wet seasons: Iron concentration at Hazaribagh sampling area ranged from 21081 to 55914 ppm and 21498 to 50991 ppm in dry and wet seasons, respectively (Table 6). Fe concentration at spot 1 (both dry and wet season) crossed the MAC for soil (50,000 mg/kg) (Chiroma *et al.* 2012)

Table 6. Cadmium, Mn and Fe concentration (ppm) in soil at various sampling points of Hazaribag area in dry and wet seasons.

Spot No	Cd Concentration (ppm)		Mn Concentration (ppm)		Fe Concentration (ppm)	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
Spot 1	2.33 a	2.10 a	733 a	601 a	55914 a	50991 a
Spot 2	1.5 b	2.0 a	641 a	562 a	45787 a	47914 a
Spot 3	1.75 ab	1.250 b	633 a	521 a	37412 a	28414 b
Spot 4	1.79 ab	1.83 ab	366b	374 b	35437 b	23414 b
Spot 5	1.25 c	0.58 c	333 b	183 b	21081 b	21497 b
Spot 6	1.50 b	0.75 c	560 ab	448ab	25416 b	24247 b
Mean	1.68	1.40	566	454	36841	32746

Means followed by same letter in a column do not differ significantly from each other at 5% level by DMRT.

Nickel (Ni) in soil in dry and wet seasons: Nickel concentration at Hazaribagh sampling area ranged from 37 to 355 and 31 to 256 ppm in dry and wet seasons respectively, (Fig.1). The highest Ni concentration was observed in main disposal point (i.e. at spot 1) which crossed the MAC for soil (50 mg/Kg) (Kloke 1980) and decreasing value was observed with increasing distance. Significant differences were found among different sampling spots. At spot 6 (outside of the embankment), 142 ppm of nickel (Ni) was observed which were significantly different from other spots, during dry season. Spot 6 may be previously contaminated before 1989 when there was no embankment to protect this area from tannery waste or huge amounts of waste water and effluents are now continuously added from other different industries (Ullah *et al.* 1999).

The concentration was different in case of wet season. There were no significant differences observed at various sampling points. The tests of significance of different sampling point were calculated by DMRT at 5% level.

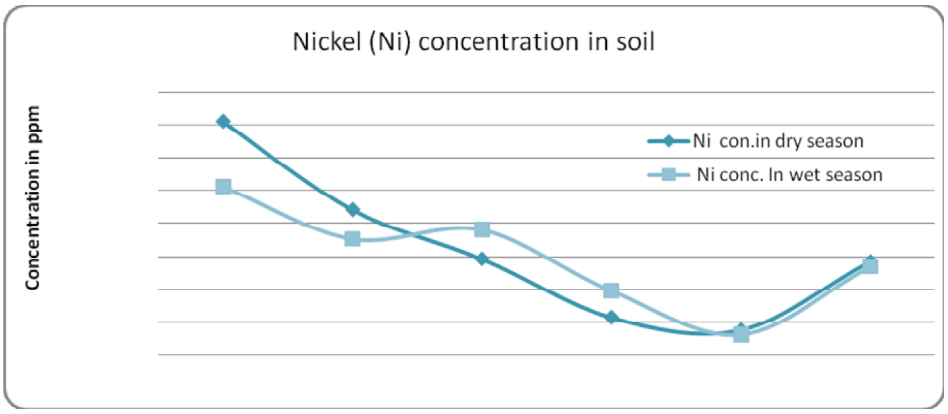

Fig.1. Ni concentration (ppm) in Soil at various sampling points of Hazaribagh area in dry and wet season.

Heavy metal concentrations in plant samples at Hazaribagh tannery area

Chromium (Cr) in plant samples in dry and wet seasons: Chromium concentrations in plant samples at Hazaribagh sampling area ranged from 171 to 1348 and 75 to 1142ppm in dry and wet seasons, respectively (Table 7). Chromium concentrations in dry season were 684, 564, 243, 171 and 1348 ppm in sampling point 2 (grass), 3 (kalmi), 4 (kalmi), 5 (grass) and 6 (water hyacinth), respectively (Table 7). Higher Cr concentration (1348 ppm) was observed in water hyacinth (spot 6) which was significantly different from other spots. Significant differences were found among other different sampling spots expect sampling point 2 and 3 i.e grass and kalmi. Similar results were also observed in wet season (Table 7). The tests of significance of different sampling point were calculated by DMRT at 5% level. Water hyacinth might be contaminated by various chromium salt that were used in tannery industries or huge amounts of waste water and effluents which are now continuously being added from other different industries. Due to variation of plant species uptake of heavy metals by plants also varies differently as reported by Chamon *et al.* (2005).

Relatively lower value of Cr was observed in all type of plant samples at the same sampling point in wet season. The lowest (75 ppm) and the highest (1142 ppm) concentrations of Cr was found at sampling point 5 and 6 i.e in grass and water hyacinth. Significant differences were found among different sampling spots. Chromium concentration observed at wet season might be due to dilution of available Cr for plant by rainfall. Elahi *et al.* (2010) reported 6591 ppm Cr in the root of water hyacinth and 756 ppm Cr in the shoot of water hyacinth at Hazaribagh area. Similar findings were also reported by Nuruzzaman *et al.* (1998). Similar findings were reported by Mark *et al.*(1995) for the uptake of heavy metals by water hyacinth in Lake Chivers which is fed by the two rivers being considered here. As long as the rate of absorption by the root is

higher than the rate of translocation to the stem and leaves, the metal concentration will be higher in the root than the tops (Mark *et al.* 1995). Chromium concentration at 6 sampling points (both dry and wet seasons) crossed MAC for plant (1-2 mg/kg) (Lake *et al*. 1984).

Zinc (Zn) in plants in dry and wet seasons: Zinc concentrations in plant samples at Hazaribagh sampling area ranged from 247 to 777 and 209 to 691 ppm in dry and wet seasons, respectively (Table 7).

Lead (Pb) in plant samples in dry and wet seasons: Lead concentrations in plant samples at Hazaribagh sampling area ranged from 44.55 to 95.6 and 28.83 to 84.17 ppm respectively, in dry and wet seasons (Table 7).

Cadmium (Cd) in plant samples in dry and wet seasons: Cadmium concentrations in plant samples at Hazaribagh sampling area ranged from 1.66 to 2.17 and 1.02 to 2.00 ppm in dry and wet season, respectively (Table 7).

Cadmium concentration at 6 sampling points (both dry and wet seasons) crossed the MAC for plant (5-10mg/kg) (Lake *et al.* 1984 and Sauerbeck 1982).

Manganese (Mn) in plant samples in dry and wet seasons: Manganese concentrations in plant samples at Hazaribagh sampling area ranged from 72 to 231 and 66 to 124 ppm in dry and wet season, respectively (Table 8).

Iron (Fe) in plants in dry and wet seasons: Iron concentrations in plant samples at Hazaribagh sampling area found to range from 354 to787 and 331 to 664 ppm in dry and wet season, respectively (Table 8).

Nickel (Ni) in plants in dry and wet seasons: Nickel concentrations in plant samples at Hazaribagh sampling area were found to range from 18 to 38 and 11 to 37 ppm in dry and wet seasons, respectively (Fig. 2).

Table 7. Chromium, Zn and Pbconcentrations (ppm) in plants at various sampling point of Hazaribagh area both in dry and wet seasons.

Spot No	Type of plants samples	Cr Concentration (ppm)		Zn Concentration (ppm)		Pb Concentration (ppm)	
		Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
Spot 2	Grass	684 b	475 a	498 b	472 b	96 a	84 a
Spot 3	Kalmi	564 b	410 a	384 b	312 b	76 a	65 b
Spot 4	Kalmi	243 a	375 c	247 c	209 c	70 b	58 b
Spot 5	Grass	171 c	75 c	318 b	331 b	45 b	29 c
Spot 6	Water hyacinth	1348 a	1142 a	777 a	691 a	80 a	25 c
Mean		602	495	445	403	73	52

Means followed by same letter in a column do not differ significantly from each other at 5% level by DMRT.

Table 8. Cd, Mn and Fe concentration (ppm) in plants at various sampling point of Hazaribagh area both in dry and wet seasons.

Spot No	Type of plants samples	Cd (ppm)		Mn (ppm)		Fe (ppm)	
		Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
Spot 2	Grass	2.17 a	2.01 a	231 a	124 a	787 a	472 a
Spot 3	Kalmi	2.08 a	2.0 a	196 ab	116 a	637 a	534 a
Spot 4	Kalmi	1.75 a	1.5a	102ab	108 a	354 a	331 a
Spot 5	Grass	1.66 a	1.02 a	72 b	66 a	683 a	664 a
Spot 6	Water hyacinth	2.17 a	2.00 a	167 ab	74 a	381 a	239 a
Mean		1.97	1.704	153	98	568	448

Means followed by same letter in a column do not differ significantly from each other at 5% level by DMRT.

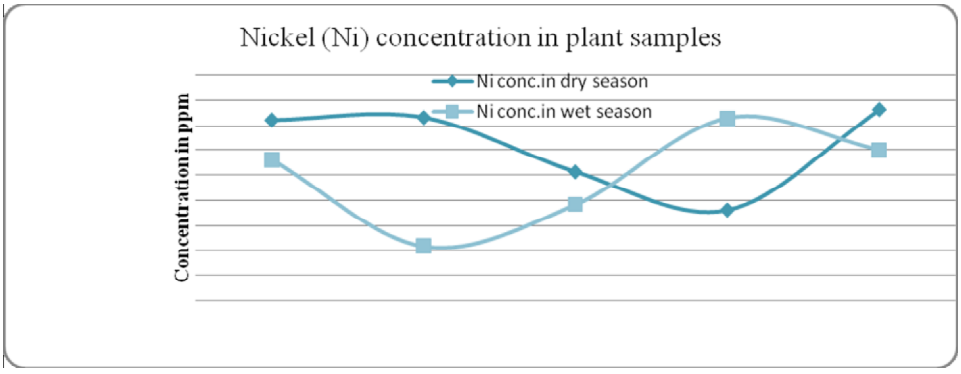

Fig. 2. Ni concentration (ppm) in plants at various sampling point of Hazaribagh area both in dry and wet seasons.

Acknowledgements

The authors are thankful to the Department of Soil, Water and Environment, University of Dhaka, Bangladesh, for providing facilities for analyses of samples.

References

Black, C.A. 1965. Methods of soil analysis. Part 1. *Am. Soc. Ago.*, Inc, Publshe. Madiso. Wisconsn, USA. pp.121-132.

Blum, W.E.H., H. Spiegeland W.W. Wenzel.1996. Bodenzutstandsinventur. Konception, Durchführung und Bewertung, EmpfehlungenZurVereinheitlichung der Vorgangsweise in Österreich.Bundesministeriumfür Land und Forstwirtschaft, Wien.2nd edition. pp. 102-103.

Chamon, A.S., M.H. Gerzabek, M.N. Mondol, S.M. Ullah, M. Rahman and W.E.H. Blum. 2005. Heavy metal uptake into crops on polluted soils of Bangladesh. I. Influence of crop and crop varieties. *J. Comm. Soil Sci. Plant analysis.* **36:** 907-924.

Chiroma, T.M., R.O. Ebewele and F.K. Hymore. 2012. Levels of Heavy Metals (Cu, Zn, Pb, Fe and Cr) in Bushgreen and Roselle Irrigated with Treated and Untreated Urban Sewage Water. *Int. Res. J. Environment Sci.* **1(4):** 1-7.

Chowdhury, F.J., S.M. Imamul Huq and M. Aminul Islam.1996. Accumulation of various pollutants by some aquatic macrophytes found in the Buriganga River. Proceeding of the 25th Bangladesh science conference.DOE 1992. Training Manual on Environmental management. pp. 121-145.

DOE (Department of Environment). 2002. Environmental Quality Standards for Bangladesh. Report. pp. 11-14.

Elahi, S.F., A.S. Chamon, B. Faiz, M.N. Mondol and M.H. Rahaman. 2010. Specification of heavy metals in soils, plants and water in Bangladesh. *Bangladesh. J. Agric. and Environ.* **5 (2):**79-97.

Immamul Huq, S.M. 1998. Critical environmental issues relating to tanning industries in Bangladesh. In. "Towards better management of soils contaminated with tannery wastes" Proceedings of a workshop at the Tamil Nadu Agri. University, Coimbatore, India, 31, January to 4 February. R. Naidu, I.R. Willett, S. Mahimairajah, R. Kookana and K. Ramasamy (eds).pp.22-28

Iwegbue, C.M.A., F. Egobueze and K.Opuene. 2006. Preliminary assessment of heavy metals levels of soil of an oil field in the Nigar Delta. Nigeria. *Inti. J. Enviro. Sci.Technol.* **3 (2):** 167-172.

Jackson, A.P. and B.J. Alloways. 1962. The transfer of Cd from agricultural soils to the human food chain *"In Biogeochemistry of Trace Metals".Advances in Trace Substances Research.* D.C. Adriano, Ed. (Boca Raton: CRC press Inc.) Pp. 109-158.

Kloke A. 1980. Orientierungslaten fur tolerierGesamtgehalteeiniger.Element in Kulturboder.Mitteilungen der *VDLUfA.***Heft1-3:** 9-11

Lake, D.L., P.W.W. Kirk and J.N. Lester. 1984. Fractionation. Characterization and speciation of heavy metals in sewage and sludge amended soil. A review. *J. Environ. Quality.***13:** 175-183.

Mark, F., Zaranyika and Timothy Ndapwadza. 1995. Uptake of Ni, Zn, Fe, Co, Cr, Pd, Cu and Cd by water hyachinth in mukuvisi and many ame rivers ; *J. Environ. Sci. Health, A.***(30) 1:**157-1469.

Nuruzzaman, M.,M.H. Gerzabek and S.M. Ullah.1995. Studis on heavy metal and microbiological pollution of soils, sediments and water systems in and around Dhaka City.Berichtan die Österr. *Akademieder Wissenschaften, ÖFZS.* 123 – 321

Nuruzzaman, M., M.H. Gerzabek, A. Islam, M.H. Rashid and S.M. Ullah. 1998. Contamination of Soil environment by the tannery industries. . *Bangladesh J. Soil. Sci.* **25(1):** 1-10.

ÖNORM. 1991. General Waste Water Emision prescription in the main drainage channel and cannel system. Nr. **179:** 184-206.

Piper. 1950. *Soil and PlantAnalysis.* Hassel Press. Adelaide. Australia. pp. 143.

Ponnamperuma, F.N.N. 1985. Chemical kinetics of wet land rice soils relative to soil fertility. In wetland soils: Characterizations, Classification and Agriculture, IRRI, Philipine.

Rahman, K. 1992. Industrial pollution and control for sustainable development. Training manual on environmental management in Bangladesh. Department of Environment, pp. 184-206.

Sauerbeck, D.1982. Welche Schwermetallghalte in Pflanzendurfennichtuberschrittenwarden. Um Wachstumsbeein trachtigungen Zuvermeiden? Landw. Forsch. Sonderheft 39. Kongressband. Pp. 108-129.

Soil Survey Staff. 1975. Reconnaissance Soil Survey Report of Dhaka District. Published by Dept. of Soil Survey, Ministry of Agriculture, Govt. of the People's Republic of Bangladesh. pp. 21-45.

Ullah, S. M., M.H. Gerzabek, M.N. Mondol, M.M. Rashid and M. Islam. 1999. Heavy metal pollution of soils and water and their transfer into plants in Bangladesh. *In. Proc. of extended Abstracts. 5th International Conference on the Biogeochemistry of Trace*

Elements (Wenzel, W. W., D.C. Adriano; B. Alloway; H.E. Doner; C. Keller; N.W. Lepp; M. Mench; R. Naidu and G.M. Pierzynski. (eds) Vienna, Austria. I: 260-61UNB, November, 2003. pp.96-108

USDA (Soil conservation Service, Soil Survey Staff), 1975. Soil Taxonomy: A basic system of Soil Classification for making and interpreting Soil Surveys. Agriculture Handbook 436, USDA, SCS, U.S. Government Printing Office, Washington, D.C.

Vdlufa, 1975. Kunigswasserauszug (Vorschlag des AgrikulturChemischen Institutes der Universität Bonn) Beurteilung der Siedlungsabfallkomposte (SAK) alsProduktionsmittel der Landwirtschaft Heft. **4/1975:** 731.

Walkley, A. and I.A. Black, 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci*. **37:** 29-38.

(Revised copy received on 23-10-2017)

J. Asiat. Soc. Bangladesh, Sci. 43(2): 223-232, December 2017

LARVICIDAL EFFICACIES OF FOUR INDIGENOUS PLANT EXTRACTS AGAINST RED FLOUR BEETLE, TRIBOLIUM CASTANEUM (HERBST) (COLEOPTERA: TENEBRIONIDAE)

MD. ADNAN AL BACHCHU[1], KISMOT ARA[2], MD. NIZAM UDDIN AND ROUSHAN ARA[3]
Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh

Abstract

An investigation was carried out on the larvicidal efficacy of four indigenous plant extracts against the 6th instar larvae of red flour beetle, *Tribolium castaneum* (Herbst) during the period of February to July 2016. The result revealed that all the four plant extracts were effective in checking insect infestation and had different toxic effects against the 6th instar larvae of red flour beetle. Average mortality indicated that castor plant extract showed the highest toxic effect (average mortality 57.78%) whereas the lowest toxicity (average mortality 27.46%) was found in the neem leaf extracts. The larval mortality significantly differed among all the concentrations of the plant extracts applied and the highest mortality (60.75%) was recorded in maximum concentration (10.61 mg/cm^2) of the plant extract. No larval mortality was observed in untreated control up to 72 HATs. Mortality percentage was also observed directly proportional to the level of concentrations of plant extracts and to the exposure period. Probit analysis of larval mortality also revealed that the castor plant extract showed the highest toxicity at different time interval among all the plant extracts applied.

Key words: Plant extracts, Larvicide, Mortality, Toxicity, *Tribolium castaneum*

Introduction

Stored agricultural products are attacked by more than 600 species of beetles, 70 species of moths and about 355 species of mites which cause quantitative and qualitative losses (Rajendran and Sriranjini 2008). These insect pests are the major cause of grain loss during post harvest storage, particularly in the tropical countries (Rajashekar *et al.* 2012). It was estimated that more than one-third of the food products are lost due to various pests during post-harvest storage (Tripathi *et al.* 2009). During storage food grain losses due to insect infestation are the most serious problem, specifically in the developing countries like Bangladesh (Dubey *et al.* 2008). Among the storage pests, Red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) is one of the most comprehensive and destructive pests of stored products, feeding on different stored grain and grain products such as peas, beans, cocoa, nuts, dried fruits and spices but milled grain products such as flour is the most preferred food (Mishra *et al.* 2012a and 2012b). They are attracted to grain with high moisture content where they encourage mold growth and produce a displeasing, musty odor.

Currently, different kinds of preventive and curative control measures are practiced to protect insect pests. Among them, chemical pesticides have been used for a long time, but have serious drawbacks (Sharaby 1988). Indiscriminate and continuous use of chemical insecticides create several problems in agroecosystem such as direct toxicity to beneficial insects, fishes and human (Goodland *et al.* 1985), pesticide resistance, increased environmental and social costs (Pimentel *et al.* 1980). To overcome these problems, it is utmost necessary to search the alternative pest control methods. The botanical pesticides which defend stored grains from pests are very helpful because of diverse distinct advantages. Botanical pesticides are of broad spectrum, safe to apply, unique in action and can be easily processed. Maximum botanical insecticides are non-hazardous and non-toxic to human. The main advantages of botanicals are that they are easily produced by farmers and are less expensive.

Interest in the use of botanical insectecides has increased over the past years (Isman 2000). Scientists in different parts of the world are working for the upliftment and induction of plant based pesticide, generally known as phytopesticide, botanical pesticide, biopesticide or natural pesticides (Siddiqui *et al.* 2009). Plant extracts contain compounds that show ovicidal, repellent, antifeedant and toxic effects in insects (Isman 2006). Previously investigations had been conducted on the toxicity effects of indigenous plant extracts against the adult stages of red flour beetle (Mahdeem 1998, Morgan 2009 and Joel 2015) but few research works had focused on the efficacies of plant extracts directly on the larval mortality of red flour beetle (Khalequzzaman and Sultana, 2006 and Yasir *et al.* 2012). Therefore, the present study was undertaken to evaluate the larvicidal efficacy of neem, thorn apple, castor and custard apple plant extracts against the larvae of *Tribolium castaneum.*

Materials and Methods

The present study on the larvicidal efficacies of four indigenous plant extracts against red flour beetle, *Tribolium castaneum* (Herbst) was conducted in the laboratory of the Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period of February to July 2016.

Collection and preparation of plant extract: The fresh mature plant leaves of custard apple (*Annona reticulata*), neem (*Azadirachta indica*), castor (*Ricinus communis*) and thorn apple (*Datura stramonium*) were collected from the HSTU campus, Dinajpur and the nearest area. Collected plant materials were air dried in shade followed by one day sun dried for 4 hours. The dried leaves were made powder separately by an electric grinder in the laboratory. The dust was passed through a 60μm mesh sieve to get fine powder. The powdered leaves were extracted in the methanol solvent. Hundred gram of every plant powders were taken separately in a 500 ml conical flask and mixed with 300 ml of methanol. The mixture was stirred for 30 minutes and then allowed to shake in the shaker machine for 24 hours. Next they were filtered through a filter paper (Whatman no. 1) and allowed to evaporate the solvents in the vacuum rotary evaporator and finally

hard different color extracts were collected. The collected crude extracts were preserved in tightly corked vials and stored in a refrigerator for further experimental use.

Preparation of food medium: Standard mixture of wheat flour with powdered dry yeast in a ratio of 19:1 was used as food medium (Park 1962). Food medium was sterilized at 60 ^{0}C temperature for 6 hours in an oven. After sterilization food was not used until at least 15 days to recover its moisture contents (Mondal 1984). In the micrometer sieve, both flour and yeast were passed through and then were mixed thoroughly for homogeneous mixing.

Collection and rearing of Tribolium castaneum: Adult beetles were collected from naturally infected wheat flour from the local market of Dinajpur town. Beetles were reared in glass beaker (500 ml) with the food medium (wheat flour). The beakers were kept in an incubator at 30 ± 0.5 ^{0}C temperature without light and humidity control. About 500 adults in each beaker were introduced with 500 g of wheat flour. The cultures were checked regularly and eggs along with larvae were separated to increase the population properly. A crumpled filter paper was placed inside the beaker for the easy movement of the bettles as well as to avoid the cannibalism of eggs. The beakers were covered with pieces of muslin cloth tightly fixed with the help of rubber bands to avoid possible escape of the beetles.

Determination of larval instars: About 500 beetles from the culture were placed in a beaker containing standard food medium. The beaker was covered with a cloth and kept in an incubator at 30 ^{0}C for egg collection. In regular interval, the eggs were collected by sieving the food medium by two sieves of 500 and 250 µm mesh separating the adults and eggs, respectively following the methods of Khan and Selman (1981). For egg collection, mainly 250 µm sieves were used. The collected eggs were kept in 60 mm in diameter petridishes and incubated at the same temperature (30 ^{0}C). Eggs hatched after 3 – 5 days and the newly hatched larvae were collected with a fine camel hair brush and then transferred to the fresh food medium for culture. The larval instars were determined by counting the number of exuviate (larval skin) deposited in the food medium (Mondal 1984). The 2nd day larvae were found as first instar larvae while the second, third, fourth, fifth and sixth instar larvae were found from the larval culture on 3rd, 6th, 9th, 12th and 16th day after hatching, respectively. Larval culture was also maintained in an incubator in the temperature at 30^0 C ± 0.5^0 C without light and humidity control. The food medium was replaced by three days interval to avoid conditioning by the larvae.

Bioassay test (mortality test): Residual film method (Busvine 1971) was used to larvicidal test of different plant extracts against the 6th instar larvae of *Tribolium castaneum* (Herbst). One ml plant extract of each dose was dropped separately on petridishes (60 mm) with the help of pipette, covering uniformly the whole area of the petridish internally. The petridishes were then kept open for sometimes to evaporate the

solvents fully. Then 10 larvae of 6th instar were released in each petridish. Only methanol solvent was used for the control treatment. Three replications were made for each dose of all the treatments. The petridishes were then kept without food in the laboratory and larval mortality was recorded at 12, 24, 36, 48, 60 and 72 hours after treatments (HAT). The percentage of mortality was corrected using Abbott's formula (Abbott 1987).

$$P = \frac{p^1 - C}{100 - C} \times 100$$

Where,

P= Percentage of corrected mortality

P'= Observed mortality (%)

C= Mortality (%) at control.

Statistical analysis: The experiment was conducted using CRD. The data obtained from the experiments were statistically analyzed by MSTATC computer program. The significance of the mean difference was tested by DMRT. The observed mortality was also subjected to probit analysis.

Results and Discussion

The results of the experiment are presented and discussed under the following subheadings:

Toxicity effect of different plant extracts against 6th instar larvae of red flour beetle: Average mortality percentages of 6th instar larvae of red flour beetle at 12, 24 36, 48, 60 and 72 hours after treatment (HAT) indicated that castor plant extract showed the highest (average mortality, 57.78%) toxic effect, whereas neem plant extract showed the lowest (average mortality, 27.46%) toxic effect (Table 1). Mortality percentages of four plant extracts were directly proportional to the time after treatment. There was significant difference ($p < 0.01$) among the toxicity effects of plant extracts applied on the 6th instar larva of *T. castaneum*. The order (highest to lowest) of toxicity effect of four plant extracts against the 6th instar larvae of red flour beetle were: castor > custard apple > thorn apple > neem. Mortality percentage also differed significantly among all the concentration level at different time interval (Table 2). The highest mortality (60.75%) was at the maximum concentration (10.61 mg/cm^2) of plant extract. Mortality percentage is directly proportional to the level of concentration. The interaction of different plant extracts of different doses at different time interval indicated that castor plant extracts showed the highest average per cent larval mortality at maximum dose (10.61 mg/cm^2) which was statistically different from all other plant extract at different concentration level (Table 3). Mortality percentages of red flour beetle of different plant extracts of different dose level at different hours were found statistically significant.

Table 1. Toxicity effect of different plant extracts against 6th instar larvae of *Tribolium castaneum* at different HAT (interaction of plant extracts and time).

Plant extracts used	Percentage of larval mortality at different time intervals						
	12HAT	24HAT	36HAT	48HAT	60HAT	72HAT	Average mortality
Neem	6.667 c	17.22 c	22.78 c	31.48 d	35.80 c	50.79 c	27.46 d
Thorn apple	9.444 bc	16.11 c	28.33 c	36.79 c	43.83 b	60.26 b	32.46 c
Custard apple	12.78 b	24.44 b	42.22 b	51.67 b	73.27 a	79.88 a	47.38 b
Castor	22.22 a	43.89 a	55.56 a	70.00 a	75.80 a	79.20 a	57.78 a
LSD	4.104	4.606	6.368	5.182	4.340	3.996	2.652
CV (%)	47.92	27.04	25.53	16.28	11.32	8.83	9.59
s_x	1.443	1.620	2.240	1.822	1.526	1.405	0.9327

HAT = Hour after treatment. Within column values followed by different letter(s) are significantly different at 5% level of probability by DMRT.

From the above result, it is apparent that among the tested four plant extracts, castor showed the most toxic effect against the 6th instar larvae of the red flour beetle. The reduction of larval population by using the leaf extracts of castor is similar to the previous findings of Basheer (2014). He reported that the castor leaf extract obtained as the best with the mortality of the larvae of *Anopheles arabiensis* was 96% after 24 hours with an LC_{50} at 0.390 mg/l, 100% mortality was observed after 48 hours with LC_{50} at 0.284 mg/l. Collavino *et al*. (2006) reported that castor bean leaf powder is effective

Table 2. Toxicity effect of different doses of plant extracts against 6th instar larvae of *Tribolium castaneum* at different HAT (interaction of dose and time).

Doses	Percentage of larval mortality at different time intervals						
	12HAT	24HAT	36HAT	48HAT	60HAT	72HAT	Average mortality
10.61	21.67 a	40.83 a	57.50 a	68.52 a	80.74 a	95.23 a	60.75 a
5.30	18.33 ab	35.83 a	52.50 a	63.24 ab	76.95 a	89.06 b	55.99 b
2.65	15.00 bc	29.17 b	43.33 b	58.98 b	67.87 b	80.78 c	49.19 c
1.33	12.50 cd	25.00 bc	37.50 bc	50.09 c	60.65 c	72.71 d	43.08 d
0.66	9.167 d	21.67 c	32.50 c	44.07 c	56.85 c	67.40 e	38.61 e
Control	0.00 e	0.00 d	0.00 d	0.00 d	0.00 d	0.00 f	0.00 f
LSD	5.027	5.641	7.799	6.346	5.315	4.895	3.248
CV (%)	47.92	27.04	25.53	16.28	11.32	8.83	9.59
s_x	1.768	1.984	2.743	2.232	1.869	1.721	1.142

HAT = Hour after treatment. Within column values followed by different letter(s) are significantly different at 5% level of probability by DMRT.

Table 3. Toxicity effect of different plant extracts of different doses against 6th instar larvae of *Tribolium castaneum* at different HAT (interaction of plant, dose and time).

Plant extracts used	Doses (mg/cm^2)	Percentage of larval mortality at different time intervals						
		12HAT	24HAT	36HAT	48HAT	60HAT	72HAT	Average mortality
Neem	10.61	13.3 cdef	33.33 de	46.67 de	53.71 ef	62.97 c	95.83 ab	50.97 ghi
	5.30	10.0 defg	30.00 de	36.67 efg	49.63 fg	55.56 cd	78.57 cd	43.41 j
	2.65	6.66 efg	16.67 fgh	26.67 fgh	50.00 fg	48.15 de	64.88 ef	35.51 k
	1.33	6.66 efg	13.33 gh	13.33 hi	17.78 i	29.63 f	39.28 g	20.00 m
	0.66	3.33 fg	10.00 hi	13.33 hi	17.78 i	18.52 g	26.19 h	14.86 m
	0.00	0.00 g	0.00 i	0.00 i	0.00 j	0.00 h	0.00 i	0.00 n
Thorn apple	10.61	20.00 bcd	36.67 cd	50.00 cde	60.37 def	66.67 c	88.4 abc	53.69 fghi
	5.30	13.33 cdef	26.67 def	43.33 def	50.00 fg	66.67 c	84.72 bc	47.45 ij
	2.65	10.00 defg	16.67 fgh	26.67 fgh	39.26 gh	48.15 de	68.98 de	34.95 k
	1.33	6.667 efg	10.00 hi	26.67 fgh	39.26 gh	40.74 ef	61.58 ef	30.82 kl
	0.66	6.667 efg	6.667 hi	23.33 gh	31.85 h	40.74 ef	57.87 f	27.86 l
	0.00	0.00 g	0.00 i	0.00 i	0.00 j	0.00 h	0.00 i	0.00 n
Custard apple	10.61	20.00 bcd	33.33 de	56.67 bcd	70.00 bcd	96.67 a	100.0 a	62.78 cde
	5.30	16.6 bcde	30.00 de	56.67 bcd	66.67 cde	92.59 ab	100.0 a	60.43 def
	2.65	16.6 bcde	30.00 de	53.33 cde	63.33cdef	85.93 ab	92.96 ab	57.04 efg
	1.33	13.33 cdef	30.00 de	50.00 cde	60.00 def	82.59 b	93.33 ab	54.88 fgh
	0.66	10.00 defg	23.33 efg	36.67 efg	50.00 fg	81.85 b	92.96 ab	49.13 hij
	0.00	0.00 g	0.00 i	0.00 i	0.00 j	0.00 h	0.00 i	0.00 n
Castor	10.61	33.33 a	60.00 a	76.67 a	90.00 a	96.67 a	96.67 a	75.56 a
	5.30	33.33 a	56.67 ab	73.33 ab	86.67 a	92.96 ab	92.96 ab	72.65 ab
	2.65	26.67 ab	53.33 ab	66.67 abc	83.33 ab	89.26 ab	96.30 a	69.26 abc
	1.33	23.33 abc	46.67 bc	60.0 abcd	83.33 ab	89.63 ab	96.67 a	66.61 bcd
	0.66	16.6 bcde	46.67 bc	56.67 bcd	76.67 abc	86.30 ab	92.59 ab	62.59 cde
	0.00	0.00 g	0.00 i	0.00 i	0.00 j	0.00 h	0.00 i	0.00 n
	LSD	10.05	11.28	15.60	12.69	10.63	9.789	6.496
	CV (%)	47.92	27.04	25.53	16.28	11.32	8.83	9.59
	s_x	3.536	3.967	5.486	4.464	3.738	3.443	2.285

HAT = Hour after treatment. Within column values followed by different letter(s) are significantly different at 5% level of probability by DMRT.

against male moth larvae, *Plodia interpunctella* HBN (Lepidoptera: Phycitinae). Castor bean oil and pure compounds of *R. communis* had been reported to exhibit high toxic effects in target animals (Kumar *et al*. 2007). Castor bean also contains the alkaloid ricinin, the polyphenolic molecule epicatechin and fatty acids in their leaves (Zahir *et al*. 2012) all which have insecticidal properties. The biological activity of castor plant extracts might be attributed to its alkaloid contents such as saponins, lectins, trypsin inhibitor etc. which caused mortality to the larvae.

Table 4. Relative toxicity (probit analysis) of different plant extracts treated against 6th instar larvae of *Tribolium castaneum* after 12, 24, 36, 48, 60 and 72 HAT.

Plant extracts used	No of larvae used	LD_{50} values (mg/cm^2)	95% fiducially limits		χ^2 values (df)
			Lower	Upper	
			12HAT		
Neem	30	1321.64	0.29	5856718	0.27 (3)
Thorn apple	30	2464.44	0.02	$2.916262E^{+08}$	0.13 (3)
Custard apple	30	443.13	1.16	168276.4	0.24 (3)
Castor	30	77.75	1.27	4730.86	0.26 (3)
			24HAT		
Neem	30	37.25	5.02	276.12	0.41 (3)
Thorn apple	30	4105.10	$1.98E^{-06}$	$8.4938E^{+12}$	0.28 (3)
Custard apple	30	23.47	6.43	85.67	0.08 (3)
Castor	30	1.50	0.26	8.59	0.14 (3)
			36HAT		
Neem	30	12.78	4.95	33.03	0.66(3)
Thorn apple	30	2.37	0.77	7.32	0.53(3)
Custard apple	30	12.91	3.07	54.17	0.87(3)
Castor	30	0.32	0.03	3.31	0.01(3)
			48HAT		
Neem	30	5.82	3.15	10.77	3.61 (3)
Thorn apple	30	0.47	0.04	5.04	0.16 (3)
Custard apple	30	4.55	1.90	10.91	0.51 (3)
Castor	30	0.0096	$4.07E^{-06}$	22.99	0.08 (3)
			60HAT		
Neem	30	4.07	2.42	6.84	0.72 (3)
Thorn apple	30	0.049	0.001	1.61	0.83 (3)
Custard apple	30	2.02	0.97	4.19	1.30 (3)
Castor	30	0.0093	$1.08E^{-05}$	8.15	0.28 (3)
			72HAT		
Neem	30	1.67	1.24	2.26	0.84 (3)
Thorn apple	30	0.002	$5.79E^{-08}$	74.72	0.21 (3)
Custard apple	30	0.96	0.55	1.67	1.07 (3)
Castor	30	$1.7E^{-07}$	$5.88E^{-32}$	$5.07E^{+17}$	0.17 (3)

HAT = Hour after treatment.
Values were based on five concentrations, three replications of 10 insects each.
χ^2 = Goodness of fit.
The tabulated value of χ^2 is 5.99 (d. f = 2 at 5% level).

Probit analysis for direct toxic effect of different plant extracts against 6th instar larvae of red flour beetle: Probit analysis for direct toxic effect of red flour beetle at 12, 24, 36, 48, 60 and 72 HAT of different plant extracts against 6th instar larvae of red flour beetle are presented in Table 4. Among the treatments, LD_{50} values at 12 HAT indicated that castor (77.75 mg/cm^2) plant extract was the most toxic followed by custard apple (443.13 mg/cm^2) plant extract while thorn apple plant extract (2464.44 mg/cm^2) was the least toxic. Castor plant extract also maintained its highest toxicity when the LD_{50} values were compared at 24, 36, 48, 60 and 72 HAT (1.50, 0.32, 0.0096, 0.0093 and 1.72E^{-07} mg/cm^2). The chi-square values were insignificant at 5% level of probability of different plant extracts at different HAT and mortality data did not show any heterogeneity.

From the results of the probit analysis on the 6th instar larvae of the red flour beetle, it is apparent that all the tested plants would be more or less effective for controlling red flour beetle but castor will be the most effective extracts against the 6th instar larval of the red flour beetle. This result is in agreement with results reported by Ramos-Lopez *et al*. (2012) who evaluated the effect of ingested ricin oil, ricinin and hexanic, acetatoethylic and methanolic extracts from 16 to 24,000 ppm on first instar *Spodoptera frugiperda* larva. All treatments with ricinin (560 ppm) and acetatoethylic extracts (1600 ppm) from *R. communis* seeds had reduced weight of the pupae by 21.6% to 4.9% respectively.

It may be concluded that the botanicals used in the present study had direct toxic effect on the 6th instar larval of *T. castaneum*. Among the tested plants, castor extracts showed the highest toxic effect. The larvicidal potential of indigenous plant extracts against *T. castaneum* has good prospects. Moreover, additional studies are needed to develop appropriate formulation and application method of *R. communis* based pesticides against stored product pest.

Acknowledgements

The authors express gratitude to the University Grant Commission, Bangladesh, for financial support through the Institute of Research and Training, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

References

Abbott, W.S. 1987. A method of computing the effectiveness of an insecticide. *J. American Mosquito Cont. Asso.* **3**(2): 302-303.

Basheer, A.G.M. 2014. *Ricinus communis* (castor) as larvicide on *Anopheles arabiensis* Patton. *Inter. J. Advan. pharma. Biol. Chem.* **3**(2): 319–328.

Busvine, J.R. 1971. A critical review of the techniques for test in insecticides. *Communication of Agricultutal Bureau*, (CAB) London, U. K. pp. 263–288.

Collavino, M., A. Pelicano and R.A. Giménez. 2006. Actividad insecticida de *Ricinus communis* L. sobre *Plodia interpunctella* HBN. (Lepidoptera: Phycitinae). *Revista Facultad de Ciencias Agropecuarias Universidad Nacional de Cuyo*. **38**: 13-18.

Dubey, N.K., B. Srivastava and A. Kumar. 2008. Current status of plant product as botanical pesticides in storage pest management. *J. Biopest.* **1**(2): 182-186.

Goodland, R., C. Watson and G. Ledec. 1985. Biocides bring positioning and pollution to third world. *The Bangladesh Observer*, 16th and 17th January 1995. p.3.

Isman, M.B. 2000. Plant essential oils for pest and disease management. *Crop Prot.* **19**: 603-608.

Isman, M.B. 2006. Botanical insecticides, de-terrents, and repellents in modern agriculture and an increasingly regulated world. *Ann. Review Entomol*. **51**: 45–66.

Joel, O.O. 2015. Efficacy of selected plant extracts against *Tribolium castaneum* Herbst in stored groundnut (*Arachis hypogaea* L.). *African J. Plant Sci.* **9**(2): 90–96.

Khalequzzaman, M. and S. Sultana. 2006. Insecticidal activity of *Annona squamosa* L seed extracts against the red flour beetle, *Tribolium castaneum* (Herbst). *J. Biol. Sci.* **14**: 107-112.

Khan, A.R. and B.J. Selman. 1981. Some techniques for minimizing the difficulties in egg counting in *Tribolium castaneum* (Herbst). *The Entomol. Record J. Vari.* **93**: 36–37.

Kumar, O., R.P.V. Lakshmana, S. Pradhan, R. Jayaraj, A.S. Bhaskar, A.B. Nashikkar and R. Vijayaraghavan. 2007. Dose dependent effect of ricin on DNA damage and antioxidant enzymes in mice. *Cell and Mol. Biol.* **53**: 92-102.

Mahdeem, H. 1998. "*Annona reticulata*". Neglected Crops. Department of Horticulture & Landscape Architecture, Purdue University. Archived from the original on 11 May 2008. Retrieved 16 April 2008.

Mishra, B.B., S.P. Tripathi and C.P.M. Tripathi. 2012a. Response of *Tribolium Castaneum* (Coleoptera: Tenebrionidae) and *Sitophilus oryzae* (Coleoptera: Curculionidae) to potential insecticide derived from essential oil of Mentha arvensis leaves. *Biol. Agri. Hort.* **28**: 34-40.

Mishra, B.B., S.P. Tripathi and C.P.M. Tripathi. 2012b. Repellent effect of leaves essential oil from *Eucalyptus globules* (Mirtaceae) and *Ocimum basilicum* (Lamiaceae) against two major stored grain insect pests of coleopterans. *Nat. Sci.* **10**(2): 50-54.

Mondal, K.A.M.S.H. 1984. A method of determining the larval instars of *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae). *Lab. Prac.* **33**(10): 120-121.

Morgan, E.D. 2009. Azadirachtin, a scientific gold mine. *Bioorg. Med. Chem.* **17**(12): 4096–4105.

Park, T. 1962. Beetles, competition and population. *Science* **138**: 1369–1375.

Pimentel, D., D. Andow, R. Dyson-Hudson. D. Gallahan, S. Jacobson, M. Irish, S. Croop, A. Moss, I. Schreiner, M. Shepard, T. Thompson and B. Vinzant. 1980. Environmental and social cost of pesticides. A preliminary assessment. *Oikos*. **34**: 125-140.

Rajashekar, Y., N. Bakthavatsalam and T. Shivanandappa. 2012. Botanicals as grain protectants. *Psyche.* **2012**: 1-13.

Rajendran, S. and V. Sriranjini. 2008. Plant products as fumigants for stored product insect control. *J. Stored Prod. Res.* **44**: 126-135.

Ramos-Lopez, M.A., M.M. Gonzalez-Chavez, N.C. Cardenas-Ortega, M.A. Zavala-Sanchez and G.S. Perez. 2012. Activity of the main fatty acid components of the hexane leaf extract of *R. communis* against *Spodoptera. frugiperda*. *African J. Biotech.* **11**: 4274–4278.

Sharaby, A. 1988. Evaluation of some myrtaceae plant leaves as protectants against the infestation by *Sitophilus oryzae* L. and *Sitophilus granarius* L. *Insect Sci. Appl.* **9**: 465-468.

Siddiqui, B.S., S.T. Ali, R.M. Tariq, T. Gulzar, M. Rasheed and R. Mehmood. 2009. GC-based analysis of insecticidal constituents of the flower of *Azadirachta indica* A. Juss. *Nat. Prod. Res.* **23**(3): 271-283.

Tripathi, A.K., S. Upadhyay, M. Bhuiyan and P.R. Bhattacharya. 2009. A Review on Prospects of Essential Oils as Biopesticides in Insect-Pest Management. *J. Pharmacol. Phyto.* **1**: 52-63.

Yasir, M., M. Sagheer, M. Hasan, S.K. Abbas, S. Ahmad and Z. Ali. 2012. Growth, development and reproductive inhibition in the red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) due to larval exposure to flufenoxur on-treated diet. *Asian J. Pharma. Biol. Res.* **2**(1): 51-5.

Zahir, A. A., A.A. Rahuman, A. Bagavan, K. Geetha, C. Kamaraj and G. Elango. 2012. Evaluation of medicinal plant extracts and isolated compound epicatechin from *R. communis* against *Poromphistomum cervi. Parasitol. Res.* **111**(4):1629-35.

(Revised copy received on 5-12-2017)

J. Asiat. Soc. Bangladesh, Sci. 43(2): 233-244, December 2017

FISH BIO-DIVERSITY AND LIVELIHOOD OF FISHERS OF DEKAR *HAOR* IN SUNAMGANJ OF BANGLADESH

I.N. SURAVI[1], M.S. ISLAM[2], N. BEGUM[3], M.A. KASHEM[4], F.J. MUNNY[5] AND F. IRIS[6]

[1 & 3]Department of Coastal and Marine Fisheries, [2]Department of Coastal and Marine Fisheries,[4] Department of Soil Science, [5] Department of Aquaculture, Sylhet Agricultural University, Sylhet-3100, Bangladesh [6] Teesside University, UK

Abstract

The study was carried out to assess the present status of fish biodiversity in Dekar *haor* and livelihood of fishermen living around the *haor* under Sunamganj district during 12 months from September 2015 to August 2016. Monthly fish samples were collected from the catches of fishermen and identified based on meristic and morphometric characteristics. A total of 51 fish species belonging to 34 genera along with two prawn species under 19 families was found. Among them catfishes were most abundant. The values of Shannon-Weiner diversity (H'), Margalef's richness (d), Pielou's evenness indices (J') and Simpson dominance indices (c) ranged from 3.36-3.78, 6.12-8.40, 0.98-0.99 and 0.97-0.98, respectively. Livelihood data were collected through direct interview from randomly selected 73 fishermen. Main occupation of fishermen is fishing. There were three age groups such as young (18-35 years), middle (36-45 years) and old group (above 46 years) where young group was mostly involved in fishing. Most of the fishermen (72.61%) were Muslims and 63% were able to sign only followed by others. Annual income of fishermen varied from Tk. 10,000-100,000. Majority of them had low savings with poor housing and sanitation facilities. Maximum fishers are interested to live in unit family owing to low income. Results of this study imply that fish diversity status was not satisfactory. Also livelihood condition of fishers was not so good. Therefore, appropriate measures should be taken to improve the livelihood of fishermen and to protect the bio-diversity of the *haor*.

Key words: Fish diversity, *Haor*, Livelihood, Fishermen

Introduction

Bangladesh possesses vast natural waterbodies in the form of canal, *beel*, *haors*, *baors*, lakes, floodplains, rivers and estuaries. *Haors* are located in the north-eastern region of Bangladesh. There are about 373 *haors* located in the districts of Sunamganj, Sylhet, Maulvibazar, Habiganj, Brahmanbaria, Netrokona and Kishoreganj, and covering an area of about 858,000 ha, which is around 43% of total area of the *haor* region (Master Plan of *Haor* Areas 2012). The most prominent *haors* are Shaneer, Hail, Hakaluki, Dekar, Tanguar, Chayer, Maker and Kawadighi *haor*. *Haor* is a marshy wetland ecosystem, which physically is a bowl or saucer shaped floodplain depression that looks like inland sea in monsoon flood. In wet season, *haors* are full of water and each of settlements looks like an isolated island in a vast waterbody but in dry season, these are dried up except deep *beels*. During winter, *haor*s contain little water and are restricted to a small

area, and a large area is filled with paddy and other crops. These natural depressed seasonal-perennial waterbodies are directly/indirectly connected with canal and river and other *haor*. These are naturally rich in fisheries resources. Waterbodies of *haor*s are productive and natural habitats of diversified fauna and flora. These are also famous for natural fish production.

*Haor*s play an important role to develop the fish diversity and maintained the livelihood condition of fishermen. Livelihood status of the *haor* dwelling fishermen mostly depends on the fisheries and other natural resources in the *haor*. On the other hand, fish diversity is also somewhat dependent on livelihood of fishermen. So fishing group is an important community to enrich the fish diversity and economics of Bangladesh. But most of the fishermen are poor and are deprived of many amenities of life. All time they have to struggle to survive. Livelihood condition of fishermen is not satisfactory at all because they do not get free access to the waterbody for catching fish in all seasons.

Dekar *haor* is one of the largest and important *haor* in greater Sylhet, Netrakona, Kishoreganj and Brahmanbaria districts. The area of this *haor* is around 252 km^2. Different sizes of *beel*s are present in the *haor*. All *beel*s are submerged during rainy season. Rivers and *haor*s are directly jointed with each other during this period. Fishes are grazed in the whole *haor*. They enjoy more space and more different types of feed without competition to each other. Growth of fishes increases with passing of time. Small indigenous species and short cycled fishes become marketable size within few months. Fishes of the *haor* are caught using various types of gear by fishermen round the year for accomplishing the expenditure of their family. So this *haor* has a great influence on fish diversity and livelihood of fishermen. But despite its innumerable importance, research has not yet been carried out on fish diversity as well as livelihood of fishermen of the *haor*. In view of the above facts, the study was undertaken to assess the fish diversity and livelihood of fishermen living around the *haor*.

Materials and Methods

Description of the haor and selection of study area: Dekar *haor* is one of the most important and the largest *haor* in Bangladesh. It lies between latitude 24°34´N to 25°12´N and longitude 90°56´E to 91°49´E. The *haor* covers four *upazilas* namely Sunamganj Sadar, Dakshin Sunamganj, Dowarabazar and Chhatak under Sunamganj district (Fig.1). It is located 60 km west away from Sylhet town, which is closed to Sunamganj town. The *haor* is consisted of 36 small, medium and large interconnecting *beels*, canals, rivers and crop lands. This open waterbody was selected as a study area.

Data collection: The data were collected for 12 months (from September 2015 to August 2016). During data collection, both primary and secondary sources were considered to interpret the results. For fish diversity assessment of the *haor*, monthly fish samples were collected directly from the catches of fishermen for identification of the species. Some samples were identified up to species on the spot and recorded the number of specimen

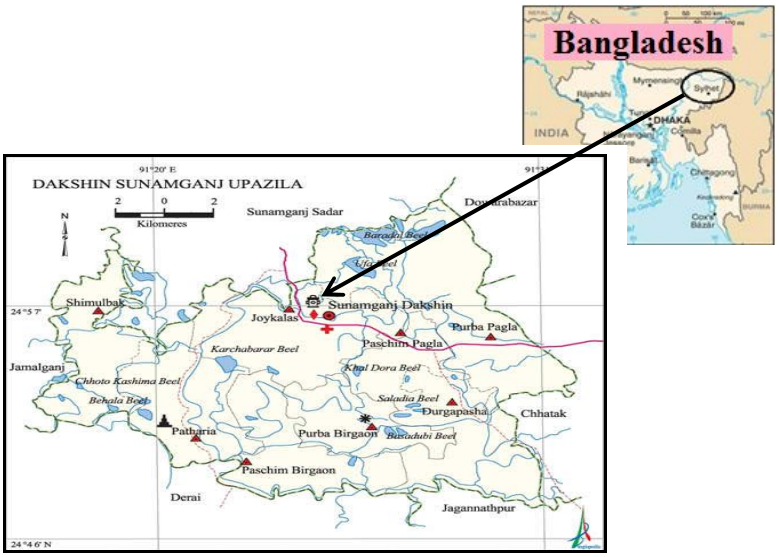

Fig. 1. Map of Dakshin Sunamganj *upazila* showing the study area.

and weighed species wise. Some samples were identified and recorded up to genus or species level following the manual and books of Talwar and Jhingran (1991) Shafi and Quddus (2001) DoF (2014) (2005) and Rahman.

Livelihood information data were collected based on field survey method from fishermen and others 4 different villages namely Noyagoan, Sultanpur, Robbaninagor, Sadarpur surrounding the *haor* under Dakshin Sunamganj *upazila*. Fishermen were randomly selected from both professional and subsistence fishermen groups living around the study area. Livelihood data were collected from 73 randomly selected fishermen and others 17 through questionnaires interviews, focus group discussion, market visit, etc where leaders of the fisher community, fish market leaders, fish traders, fry traders, local leaders, school teachers and community people were also present. Secondary data were collected from Dakshin Sunamganj *Upazila* Fisheries Office, District Fisheries Office of Sunamganj district, books, journals, reports and NGOs.

Fish diversity data analysis: Diversity of species assemblage was analyzed by Shannon-Weiner index (H') (Shannon 1949, Shannon and Weiner 1963, Pielou 1966, Margalef 1968, Ramos *et al.* 2006), species richness was measured by Margalef index (d) evenness was estimated by Pielou's index (J') and dominance was determined by Simpson index (c). Values of Shannon-Weiner diversity index and Margalef richness index, Pielou's evenness index and Simpson dominance index were calculated using the following formula :

Shannon-Weiner diversity index (H′): $\sum_{i=1}^{s} [Pi \times \log (Pi)]$

Where, H′ = Shannon-Weiner index

Pi = ni/N

ni = No. of individuals of a species

N = Total number of individual fish

S = Total number of fish species

Margalef species richness (d): *(S-1)/log (N)*

Where, S = Total fish species

N = Total individual fish

Pielou's evenness index (J'): *H (s)/H(max)*

Where, *H* (s) = the Shannon-Weiner information function.

H (max.) = The theoretical maximum value for H(s) if all species in the sample were equally abundant.

Simpson dominance index (c): $\sum_{i=1}^{s} (ni/N)^2$

Where, ni = number of individuals in the 'each' species
N = Total number of individual fish
S = Total number of fish species

Socioeconomic and livelihood data analysis: All collected socioeconomic and livelihood data were calculated using the following formula :

$$\text{Mean,} \quad X = \frac{-\sum X_i}{N}$$

Where, $\sum X_i$ = Sum of all of the numbers in a list
N = Total number of items in that list

Range: It is the difference of the higher and lower observation of the distribution.

Percentage: It is the rate/number/amount in each hundred.

Statistical analysis: A one way analysis of variance (ANOVA) was used to test for significant difference in Shannon-Weiner diversity index (H′), Pielou's evenness index (*J'*) and fish abundance among months. All multivariate analyses were performed by software PRIMER V6 (Plymouth Routines Multivariate Ecological Research) (Clark and Warwick 1994). All socioeconomic and livelihood data were stored and processed through computer software and analyzed using Microsoft Excel and STATISTICA software.

Results and Discussion

Fish diversity of Dekar haor: Large number of freshwater fish species are still available in this largest freshwater wetland. During the study period 51 species of fish of which 8 species of carps, 4 snakehead, 8 perches, 3 eels, 11 catfishes, 6 barbs, 1 minnows, 2 clupeids and 8 other fishes including prawn namely *Macrobrachium rosenbergii* and *Macrobrachium malcolmsonii* under 19 families were recorded (Table 1). It was found that 23 fish species were abundant, 10 common and 18 rare out of 51 fish species (according to IUCN, 2015). Of 51 species, 47 were indigenous and the rest four exotics species. Among exotics, carpio (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) were dominant in the *haor*. Pandit *et al*. (2015) reported a total of 56 fish species including prawn species belongs to 21 families from the *haor* Soma Nadi *Jalmohal* of Derai *upazila*, Sunamganj. Among 56 species, 26 were commonly available (47%), 18 moderately available (32%) and 12 rarely available (21%). Out of 56 species, 8 were carps, 12 catfish, 9 barbs and minnows, 4 snakehead, 4 eel, 10 perches, 3 loaches and 6 miscellaneous including 3 prawn species. Sayeed *et al*. (2015) reported a total of 82 fish species belongs to 50 genera of 22 families under 9 orders, of which 75 were indigenous and 7 exotic in Hakaluki *haor*.

Fishermen in this *haor* were classified according to their fishing gear used. Nine types of gear were considered during the experimental period (Table 2). Most of the fishermen (31.51 and 16.4%) used gill net and seine net, and only 2.74% used fish trap-b (*gui*) and c (*polo*), respectively for catching fish. Fisheries resources are now under great threat due to man-made obstacles (fishing by dewatering of *beels,* use of gill net, harvesting of undersized fishes and brood fishes, use of insecticides, embankment, exploitation of aquatic vegetation, etc) and various environmental degradations (siltation of the *beels*, lack of water around the year, lack of natural food for fishes, water quality degradation, climate/seasonal changes, etc). For these reasons, fish diversity of the *haor* has been reducing day by day.

Fish species diversity indices : Shannon-Weiner diversity index (H'): The highest (3.3556) Shannon-Weiner index was recorded in February and the lowest (3.7799) in September. Kanon (2014) reported the highest value (3.12) in June and the lowest (2.9) in January of Shannon-Weiner index of Konoskhai *haor*, Sunamganj, which was lower than the findings of the present study.

Margalef richness index (d): The lowest (6.1185) and the highest (8.4023) values of Margalef index were recorded in February and September, respectively. Kanon (2014) reported the Margalef's index ranging from 2.7 (December) to 3.02 (July) in Konoskhai *haor*, which was less than the findings of this study.

Table 1. List of indigenous and exotic fishes recorded in Dekar *haor* during study period.

Sl. No.	Family name	Local name	English name	Scientific name	Remarks (IUCN, 2015)
1.	Cyprinidae	Rui	Indian major carp	*Labeo rohita*	Rare
2.	Cyprinidae	Catla	Indian major carp	*Jubilant catla*	Common
3.	Cyprinidae	Kali baush	Black rohu	*Labeo calbasu*	Abundant
4.	Cyprinidae	Mrigal	Indian major carp	*Cirrhinus cirrhosus*	Rare
5.	Cyprinidae	Gonia	Kuria labio	*Labeo gonius*	Abundant
6.	Cyprinidae	Silver carp	Silver carp	*Hypophthalmychthys molitrix*	Common
7.	Cyprinidae	Grass carp	Grass carp	*Ctenopharyngodon idella*	Common
8.	Cyprinidae	Carpio	Common carp	*Cyprinus carpio*	Abundant
9.	Channidae	Shol	Snakehead murrel	*Channa striatus*	Abundant
10.	Channidae	Taki	Spotted snakehead	*Channa punctatus*	Abundant
11.	Channidae	Chang	Asiatic snakehead	*Channa orientalis*	Rare
12.	Channidae	Gajar	Giant snakehead	*Channa marulius*	Rare
13.	Anabantidae	Khalisha	Striped gourami	*Colisa fasciatus*	Rare
14.	Anabantidae	Chuna khalisha	Honey gourami	*Colisa chuna*	Rare
15.	Anabantidae	Lal khalisha	Red gourami	*Colisa lalia*	Rare
16.	Anabantidae	Koi	Climbing perch	*Anabus testudineus*	Common
17.	Centropomiodae	Kata chanda	Round glass perchlet	*Chanda baculis*	Abundant
18.	Centropomidae	Lal chanda	Indian glass perch	*Chanda ranga*	Rare
19.	Centropomidae	Nama chanda	Elongated glass perchlet	*Chanda nama*	Abundant
20.	Nandidae	Meni	Mud Perch	*Nandus nandus*	Abundant
21.	Mastacembelidae	Guchi baim	Striped spiny eel	*Mastacembelus pancalus*	Abundant
22.	Mastacembelidae	Tara baim	One striped spiny eel	*Macrognathus aculeatus*	Abundant
23.	Mastacembelidae	Lal baim	Tire-track spiny eel	*Mastacembelus armatus*	Abundant
24.	Bagridae	Gulsha	Long whiskered catfish	*Mystus gulio*	Common
25.	Bagridae	Bujuri	Long bled catfish	*Mystus tengra*	Abundant
26.	Bagridae	Tengra	Striped dwarf catfish	*Mystus vittatus*	Abundant
27.	Bagridae	Air	Long whiskered catfish	*Sperata aor*	Rare
28.	Claridae	Magur	Walking catfish	*Clarius batrachus*	Abundant
29.	Heteropneustidae	Shing	Stinging catfish	*Heteropneustes fossilis*	Abundant
30.	Schilbeidae	Batashi	River catfish	*Pseudeutropius atherinoides*	Common
31.	Schilbeidae	Bashpata	Gangetic ailia	*Ailia coila*	Common
32.	Schilbeidae	Bacha	River catfish	*Eutropiichthys vacha*	Rare
33.	Siluridae	Modhu pabda	Butter catfish	*Ompok pabda*	Common
34.	Siluridae	Boal	Freshwater shark	*Wallago attu*	Abundant
35.	Cyprinidae	Phul chela	Barb	*Chela phulo*	Rare
36.	Cyprinidae	Lamba chela	Barb	*Chela bacaila*	Rare
37.	Cyprinidae	Mola	Barb	*Amblypharyngodon mola*	Common
38.	Cyprinidae	Dhela	Barb	*Rohtee cotio*	Rare
39.	Cyprinidae	Jatpunti	Spot fin swamp barb	*Puntius sophore*	Abundant
40.	Cyprinidae	Tit punti	Fire fin barb	*Puntius ticto*	Abundant
41.	Cyprinidae	Darkina	Top minnow	*Esomus dandricus*	Rare
42.	Clupeidae	Chapila	Indian river shad	*Gudusia chapra*	Abundant
43.	Clupeidae	-	Indian river shad	*Gudusia minminna*	Abundant
44.	Belonidae	Kakila	Freshwater gar fish	*Xenentodon cancila*	Abundant
45.	Cobitidae	Gutum	Guntea loach	*Lepidocephalus guntea*	Rare
46.	Gobiidae	Baila/bele	Bar-eyed goby	*Glossogobius giuris*	Common
47.	Notopteridae	Chitol	Humped feather back	*Notopterus chitala*	Rare
48.	Palaemonidae	Golda	River prawn	*Macrobrachium rosenbergii*	Rare
49.	Palaemonidae	Gura chingri	Monsoon river prawn	*Macrobrachium malcolmsonii*	Abundant
50.	Tetraodontidae	Choto tepa	Oscillated puffer fish	*Tetraodon cutcutia*	Abundant
51.	Cichlidae	Tilapia	Tilapia	*Oreochromis mossambicus*	Rare

Pielou's evenness index (J'): The highest evenness value (0.9965) was observed in February and the lowest (0.9885) in November. Alam *et al*. (2015) recorded Pielou's index as 0.67, 0.59 and 0.67, respectively in three *beel*s (Patasinghra, Shalkatua and Hawagulia of Kawadighi *haor*), Moulvibazar, which were lower than the present findings.

Table 2. Fishing gears used in Dekar *haor* during study period.

Groups	Types of gear	
Fish net	Gill net	*Current jal*
	Seine net	*Ber jal*
	Lift net	a. *Vassal/Khorajal* b. *Dharma jal*
	Cast net	*Jhaki jal*
	Push net	*Thela jal*
Fish trap		a. *Tengra chai* b. *Gui* c. *Polo* • *Dori* • *Kon* • *Ronga*
Hooks and line		a. *Borshi* b. *Hand borshi*

Simpson dominance index (c): The uppermost dominance value (0.9819) was determined in June and the lowest (0.9747) in February. Kanon (2014) demonstrated Simpson index ranging from 0.91 (January) to 0.94 (June) in Konoskhai *haor*, which was coincided with the findings of the present study. It is noted that water area of the *haor* is gradually/drastically increased after first/mid/last April in a year due to heavy shower and upstream run-off/flash flood. Fishes are dispersed in the whole *haor*. Fishermen freely catch fishes from the non-restricted water using different types of gear for their livelihood. Fishermen catch gradually increase with the increases of time up to a certain period, while water of the *haor* gradually recedes, comparatively a good amount of fishes are caught by fishermen. Peak season of fishing is started from June/July and continue up to October/November in a year. After that water is limited to certain areas and fishermen are not allowed for catching fish from restricted/leased water-bodies. For these causes, monthly catch by fishermen varied with season and water availability.

Livelihood status of fishermen

Age structure: Age structure of fishermen was divided into three age groups such as young (18-35 years), middle (36-45 years) and old age (above 46 years). It was observed that young group was the highest (59%) and old was the lowest (19%) among all gear users. Within fishing gears, young group was the highest (100%) in trap-c (*polo*) users and in the middle group the highest percentage (66.67%) was observed for push net whereas the highest value (50%) was estimated for old group in case of trap-b (*gui*) users. Rabbani (2007) reported that age group of 25-50 years was the highest (46.67%) and more than 50 years were the lowest (25%) of fishermen in the Karatua river, Bogra. Roy (2010) stated that young group was the highest (42%) and old group was the lowest (34%) among all gear users, these were consistent with the findings of the present study.

Family size: About 48% fishermen had medium family, 31% small and 21% large. Within the fishermen according to gear types, the highest percentage (100%) of medium family belonged to cast net, push net and trap-c (*polo*) users, and the lowest of small family was recorded in long line users. The highest value (50%) of large family was observed in trap-b (*gui*) users. Roy (2010) reported the largest value (83.33%) of medium family belongs to trap-b (*gui*) users and the lowest of large family among all gear users.

Religion: Sampled fishermen were distributed as 72.61% the Muslims and 27.39% the Sonatans, respectively in the *haor*, which was in agreement with the findings of Mahmud (2007) and Roy (2010), who stated that the highest 74 and 71% fishermen were the Muslim whereas only 26 and 29% the Hindus (Sonatans). Himu (2014) mentioned that majority (95.14%) of fishermen was the Muslims and minority (4.85%) the Hindus in study area of Hakaluki *haor*, which was higher than the findings of the present study.

Educational status: Sixty three percent (63%) fishermen had ability to sign, 26% no education and 7% primary. On the other hand, only 3% and 1% fishermen had JSC (Junior School Certificate) and SSC (Secondary School Certificate). Rabbani (2007) reported 20% riverine fishermen illiterate, 71.67% primary and only 8.33% secondary level. It might be due to the majority of the fishermen had no education. Roy (2010) stated that 73% fishermen of Pagnar *haor* in Sunamganj had no education, 21% primary and only 6% secondary. Most of sampled fishermen were compelled to engage in fishing profession at their early stage due to poor economic condition of their parents and lack of awareness about education.

Annual income: A 51% fishermen had moderate income and 11% low income whereas 38% high income. Annual income varied within different types of gear used by fishermen (Fig. 2). Majority of the cast net (100%) and gill net (82.61%) users had moderate income and most of the push net and multiple gear users (66.66%) were fell in low income group. Maximum multiple gear users (73.34%) had high income. Fishermen opine that their income depend on the availability of fishes in the *haor*. The quantity of fishes in the *haor* has been decreasing in every year owing to natural and man-made

causes. On the whole life, fishermen are at risk and they have no refreshment and no different taste of life. So many fishermen are switching over fishing profession to other

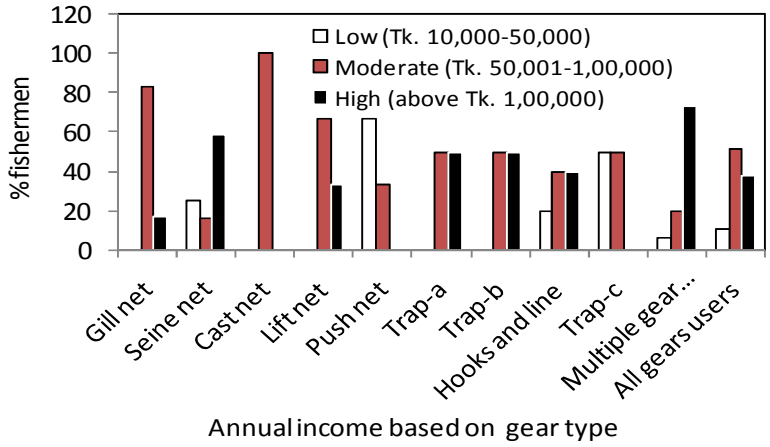

Fig. 2. Annual income of fishermen of Dekar *haor*.

activities to enjoy better life. Roy (2010) stated that the highest (7.14%) annual income was in long line fishermen under high annual income category. Comparatively maximum income (85.72%) was recorded in long line users under moderate income and the highest (50%) income was found in trap-b (*gui*) users under low income. He also concluded that long line fishermen earned comparatively higher income than other two categories. Holder (2002) reported annual income from fishing of all gear users as Tk. 89,199.96 and 96,199.92 in Doba *beel* and Chara *beel*, respectively. Himu (2014) observed that only 21.37% fishermen continued their livelihood generation through fishing. Majority (78.63%) of them took other occupations due to low income from fishing. He concluded that livelihood of fishermen were not satisfactory.

Savings: Savings of *haor* fishermen are presented in Fig. 3. About 38% respondents had medium savings, 41% low, 11% no savings and 10% high savings. Within fishing gear categories, majority (75%) of trap-a (*chai*) users had medium savings and 66.67% push net users had no savings at all, whereas about 50% trap-b (*gui*) users had high savings. It was also found that maximum of trap-b (*gui*) and multiple gear users were saved from their income. Roy (2010) reported that low savings group was the highest (55%) and high savings group was the lowest among all gear users. He also added that within fishing gear users no savings group was the highest (35.72%) in cast net and long line users, low savings group was the highest (83.33%) in trap-b (*gui*) users and medium savings group (46.66%) was in gill net users.

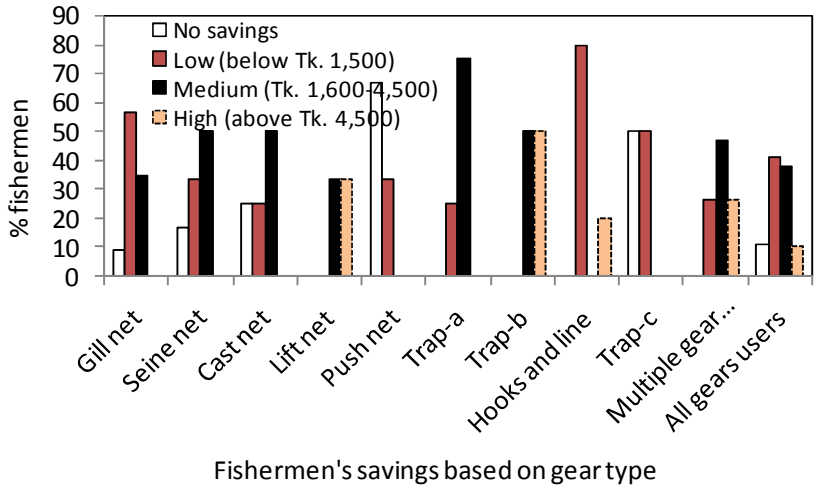

Fig. 3. Savings status of fishermen of Dekar *haor*.

Housing and health condition: There were two types of house in the study area namely thatched house and half building (brick walls with tin roof). Data of the present study revealed that 83.56% fishermen had thatched houses and 16.44% half building. Ahmed (2002) found that 62% fishermen had thatched houses in Mymensingh. Roy (2010) observed that majority of fishermen (83%) had thatched house and 17% half building in the Pagnar *haor*, Sunamganj. Himu (2014) noted that about 66.66% fishermen had thatched house, while 26.66% half building and only 6.66% building surrounding the Hakaluki *haor*. Health facilities of fishermen in studied area were very poor and found that 54.79% fishermen households dependent on village doctors who do not have any knowledge regarding medical science, 23.28 and 19.18% on quack doctor and municipal hospital, respectively while only 2.74% received health service from MBBS doctor. Roy (2010) mentioned 85% fishermen in Pagnar *haor*, Sunamganj dependent on village doctors and 15% received health service from *upazila* hospital. Alam (2006) reported only 42% farmers received the medical facilities from MBBS doctor and *upazila* health complex while the rest 58% dependent on village doctor and others in Mithapuqur *upazila*, Rangpur.

Sanitation facilities: Sanitation facilities of fishermen living around the *haor* were not good. Data showed that 79.45% had open toilets surrounded by temporary fencing while 20.55% sanitary. Alam (2006) reported that only 24% had good sanitation. Roy (2010) observed that 40% had open toilets, only 8% sanitary and 52% had no toilets. Himu (2014) found that most of the fishermen had the worth toilet facilities, 58.33% had open toilet, whereas 3.66% no toilet facility.

Land area: Majority (49%) of fishermen had small land whereas only 14% large. On the other hand, 37% respondents had medium land. According to gear types the largest value (66.66%) of small land holder in lift net users and in case of long line users about 40% had large whereas 66.66% push net users had medium land.

Family type: There were two types of family in the study area such as joint family and unit family. Approximate 16.44% fishermen lived in joint family and 83.56% in unit family. Roy (2010) noted that 56% fishermen lived in joint family and 44% in nuclear (small) family. Himu (2014) observed that most of fishermen had nuclear family (90%) while few (10%) joint family, which was coincided with the findings of the present study. Joint/large family is splitting owing to majority respondents are interested to live separately due to lack of income.

Results of the study indicate that indiscriminate fishing activities using different types of gears by fishermen caused great loss of all varieties of fishes and the status of fish bio-diversity is now moderate to poor. Most of the fishermen's income is much lower than the national per capita income. Fishermen's savings are very poor. Their livelihood condition is not good. Majority of the fishers are changing their livelihood as fish diversity and fish production of the *haor* are decreasing in every year due to man-made and natural causes. Government and other organizations should come forward for taking urgent actions to protect the biodiversity of the *haor*, which will help to improve fishermen's livelihood and fish diversity will be saved.

Acknowledgements

The authors are indebted to the Krishi Gobeshona Foundation (KGF) for providing fund to conduct the research under the project entitled "Farm Productivity Improvement in *Haor* areas through Integrated Farming Systems Approach".

References

Ahmed, N. 2002. Socio-economic aspects of freshwater prawn culture development in Mymensingh. Bangladesh. A report prepared for ICLARM, Dhaka. 25 p.

Alam, M. J. 2006. Status of fish farming and livelihood of the fish farmers in Mithapukur, Rangpur. M. S. Thesis (unpublished), Department of Fisheries Management, Bangladesh Agricultural University (BAU), Mymensingh. 81 p.

Alam, M. T., M. A. H. M. Kamal, M. A. Sayeed and M. A. Kabir. 2015. Impact of Aquaculture on Fish Biodiversity in Kawadighi*Haor* of North- East Region of Bangladesh. SAU Res. Prog. Rep. No. **02**, Sylhet Agricultural University, Sylhet, Bangladesh, pp. 51-56.

Clarke and Warwick, 1994. Change in Marine Communities: An Approach to Statistical Analysis & Interpretation. Natural Environment Research Council, UK, 144 p.

DoF (Department of Fisheries). 2014. Freshwater Fishes of Bangladesh. Department of Fisheries, Bangladesh. 213 p.

Himu, M. H. 2014. Impact of fish biodiversity on fishers livelihood of Hakaluki *haor* in Bangladesh. M. S. Thesis (unpublished), Department of Fisheries Technology and Quality Control, Sylhet Agricultural University, Sylhet. 60 p.

Holder, D. K. 2002. Studies on the availability of small indigenous species (SIS) of fishes and socioeconomic condition of fishers in two beels of rice fields. M. S. Thesis (unpublished), Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh. 136 p.

IUCN (International Union for Conservation of Nature) Bangladesh. 2015. Red List of Bangladesh, Vol. 5: Freshwater Fishes, Bangladesh Country Office, Dhaka, Bangladesh. pp. xvi+360p.

Kanon, M. H. 2014. Diversiity of Indigenous Fish Species in Konoskhai *Haor*. M.S. Thesis (unpublished) submitted to the Department of Fish Biology and Genetics, Sylhet Agricultural University (SAU), Sylhet. 49 p.

Mahmud, T. A. 2007. Fish biodiversity and socio-economic conditions of the fishing community in some selected areas of Chalan *beel*. M. S. Thesis (unpublished) submitted to the Department of Aquaculture, BAU, Mymensingh. pp. 27-53.

Margalef, R. 1968. Perspectives in Ecological Theory. Chicago Illinois University. Chicago Press. 111 p.

Master Plan of Haor Areas. 2012. Draft Final Report, Vol. II, Ministry of Water Resources, Bangladesh *Haor* and Wetland Development Board, Government of the People's Republic of Bangladesh, pp. 1-18.

Pandit, D., M. Kunda, M. J. Islam, M. A. Islam and P. P. Barman. 2015. Assessment of present status of fish diversity in Soma Nadi*Jalmohal* of Sonamganj in Bangladesh. *J. Sylhet Agril. Univ.*, **2** (1): 127-135.

Pielou. 1966. The measurement of Diversity in Different Types of Biological Collections. *Theort. Biology*, **13**:131-144.

Rabbani, M. G. 2007. Study on the fisheries and socio-economic condition of fishermen of Karatua river. M. S. Thesis (unpublished), Department of Fisheries Management, BAU, Mymensingh. 85 p.

Rahman, A. K. M. 2005. Freshwater Fishes of Bangladesh. 2nd ed. Zoo. Soc. of Bangladesh, Dhaka, Bangladesh. 394 p.

Ramos, S., R. K. Cowen, P. Re´ andA. A. Bordalo. 2006. Temporal and patial distribution of larval fish assemblages in the Lima estuary (Portugal). Estuarine, Coastal and Shelf Science, **66**: 303-314.

Roy, K. C. 2010. Fish biodiversity and the livelihoods of the fishing community in Pagnar*haor* under Jamalgonjupzila in Sunamgonj district. M.S. Thesis (unpublished), Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

Sayeed, M. A., R. C. Deb, D. Bhattarcharjee, M. H. Himuand and M. T. Alam. 2015. Fish biodiversity of Hakaluki*haor* in north-east region of Bangladesh. SAU Res. Prog. Rep. No. **02**, Sylhet Agricultural University, Sylhet, Bangladesh, pp. 71-78.

Shafi, M. and M. M. A. Quddus. 2001. *Bangladesher Matshaw Sampad (Bangla)*. Kabir Publications, Dhaka. 485 p.

Shannon, C. E. 1949. Communities in the presence of noise proceeding of the Institute of Radio Engineers, **37** (1): 10-21.

Shannon, C. E. and W. Weiner. 1963. The mathematical Theory of communications. University of Illinois Press, Urbana, **II**, 125 p.

Talwar, P. K. and A. G. Jhingran. 1991. *Inland fishes of India and adjacent countries*. Volume 1 and 2. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Calcutta. 1158 p.

(Revised copy received on 10-12-2017)

J. Asiat. Soc. Bangladesh, Sci. 43(2): 245-257, December 2017

COMPARATIVE STUDY OF CATCH IN OPEN WATER FISH HABITATS BOTH INSIDE AND OUTSIDE THE EMBANKMENT OF MEGHNA DHONAGODA IRRIGATION PROJECT

MD. MOTAHER HOSSAIN[1*], MOHAMMAD SHAFI[2], MD. KAWSER AHMED[3] , MOHAMMAD ABU JAFOR BAPARY[1] AND MD. LOKMAN HOSSAIN[4]

[1]*Department of Fisheries Technology and Quality Control, Faculty of Fisheries, Sylhet Agricultural University, Sylhet-3100, Bangladesh*

[2]*Department of Fisheries, Faculty of Biological Sciences, University of Dhaka, Dhaka-1000, Bangladesh*

[3]*Department of Marine science, University of Dhaka, Dhaka-1000, Bangladesh*

[4]*Department of Zoology, Dhaka College, Dhaka-1000, Bangladesh*

Abstract

A comparative study of production /catch in open water fish habitats was conducted both inside and outside the embankment of Meghna Dhonagoda Irrigation Project (MDIP). Very low production was observed in the khal/canal (24.32 kg /ha and 26.45 kg /ha), inundated paddy field/ floodplain (1.99 kg / ha and 2.24kg / ha) in inside the embankment in 2003-2004 and 2004-2005, where the production/Catch per unit area was higher in khal (531.56 kg /ha and 528.77kg /ha), floodplain (38.18 kg /ha and 33.84 kg /ha) in outside during the same years. Beside these, the production/catch was recorded in irrigation canal (13.90 kg /ha and 21.94 kg /ha) in inside the embankment of both the years. On the other hand, the catch was recorded in Meghna river (137.87 kg /ha and 96.27 kg /ha) and in Dhonagoda river (124 kg /ha and 85.92 kg /ha) in outside the embankment of both the years respectively. The production was little bit higher in inside open water habitats in 2004-2005, escaped fishes from the ponds were also caught in the inside open water habitats in 2004-2005 due to the over flooding of ponds caused by excess rainfall in September 2004. In both the years, the highest production of inside habitats was in khal, followed by irrigation canal and inundated paddy field/ floodplain. In case of outside habitats, the highest production was in khal, followed by Meghna river, Dhonagodariver and floodplain during both the years of study. Monthly estimated catch regarding the production of the equal sample area of the same habitats between the two zones are statistically significant ($p<0.05$) in both 2003-2004 and 2004-2005.

Key words: Catch, Open water, Fish habitats, Embankment, MDIP

Introduction

The fisheries resource of Bangladesh is one of the most important one in Asia covering about one percent of the total world fish catch (FAO 1997 and Hossain 1998). In the early sixties, open water fisheries contributed about 70-75% of the total fish production, which in recent years has dropped to 50% (DOF 1999). According to BFRSS (2003-2004), the inland open water contributed 34.83% of the total fish production which dropped to 27.79% in 2014-15. According to DOF (2016), total fish production was

[*] Corresponding author: E-mail: motaher03@yahoo.com

36.84 lakh mt, 3.65% to GDP and Bangladesh became 4th in inland open water fish production in 2014-2015. So, fisheries sector plays an important role regarding employment generation, animal protein supply, foreign currency earning and poverty alleviation. About 12 million people are directly or indirectly involved in this sector. Labour employment in this sector has been increasing approximately by 3.5% annually. In Bangladesh, fish provides up to 63% of animal proteins consumed (BBS 2001and DOF 2005).

Over 12.4 million people are estimated to be engaged in one way another inland fisheries production, this population consists of 1.4 million full-time professional fishermen and over 11 million part-time or occasional fishermen and a small percentage of fish farmers. Fisheries sector provides 7% of our total national employment. Large numbers of people depend directly or indirectly on the fisheries sector for their livelihood.

Of all the sources, the inland open water is the most important source of fish production in Bangladesh. Major production comes from the naturally grown and bred fish from the open water system. The open water and the floodplain are very rich in natural fish food and as a result the open water fishes do not require supplementary feeding. The open water is also a very important source of employment to rural fishermen.

In Bangladesh, the fish catch from the inland open water capture fishery is decreasing while the demand for fish is increasing along with the increase in population. The fish yield from the rivers and estuaries except Sundarban area has decreased from 207,766 mt in 1983-84 to 173,410 mt in 1989-90, 138,746 mt in 1992-93, 137,848 mt in 2002-2003 and 137,337 mt in 2003-2004 respectively (BFRSS 1983-84 to 2003-2004).

The details of the impact of flood control projects on fisheries are as follows: loss of catch through loss of fish habitat, reduction in catch per unit area (CPUA) reduced fish density / abundance, increase fishing effort, reduced biodiversity, reduction in the number of migratory fish and number of migrations, disruption of fishermen community structure, increased fish capture at regulators, reduced opportunity for mitigation measures and reduced potential for stock enhancement (FAP 17 1995). In surveys of fishermen, up to 75% of the reduction has been blamed on the FCDI project (Nishat and Bhuiyan 1995). Ali and Zaman (1989) have depicted the trends of effects of flood control and drainage (FCD) projects on floodplain loss and floodplain fish production in Bangladesh.

The inland open water like floodplains and beels were once exceptionally rich in wild fish, which contributed significantly to national nutritional requirements. But in recent years, fish production from these sources has declined alarmingly for many reasons such as construction of embankments, regulators and sluice gates, water pollution, over fishing etc. (BCAS 1991 and DOF 1995). The FAP-12 (1992a) observed that FCD and FCDI projects had major negative impacts on capture fisheries, resulting from substantial reductions in the areas of inundated floodplains and permanent beels and by the blockage

of fish migration routes. Many fishermen lost their livelihood or been diverted to river fisheries, leading to over fishing in these areas, adversely affecting the fish migration potential.

The Meghna Dhonagoda Irrigation Project (MDIP) is a medium scale, flood control, drainage and irrigation (FCD/I) project. The project area is composed of 15 unions of Matlab North *upazila* under Chandpur district. The area is an island circumscribed by the Meghna and Dhonagoda rivers. It was constructed between 1982 and 1987. It provides flood control and drainage to 17584 ha area of land and irrigation to 13602 ha area. The whole embankment is 60 km. The whole project area is flat and used to remain submerged by flood water from April-May to November. Before construction the embankment there were large numbers of khals serving as drainage channels as well as channels for transport. A large segment of the human population (fishermen, landless and other disadvantaged people) was dependent on this rich capture fishery production for their livelihood and employment throughout the duration of monsoon inundation. But after construction of embankment, the loss of capture fishery has devastated the life of many people who were dependent on this capture fishery for their livelihood.

Halls *et al.* (2000) stated that fish production in floodplains river systems is largely dependent upon the timing, extent and duration of flood pulse, all of which can be severely modified by hydraulic engineering. CPUA was found to be 38-51% lower inside the Pabna Irrigation and Rural Development Project (PIRDP) flood control, drainage and irrigation scheme during both sampling years, although fishing effort could not account for these differences. The inland open water like floodplains and beels were once exceptionally rich in wild fish, which contributed significantly to national nutritional requirements. But in recent years, fish production from these sources has declined alarmingly for many reasons such as construction of embankments, regulators and sluice gates, water pollution, over fishing etc. (BCAS 1991 and DOF 1995) and the objectives of this study were

- To know the inland open water habitat-wise catch/production both inside and outside the embankment of MDIP
- To compare the catch between the habitats of inside and outside the embankment.

Materials and Methods

Catch Assessment Survey : Fish (habitat-wise) catch assessment survey was performed to find out extent of the existing capture fishery, gear-wise catch per unit effort, catch per unit area of different open water fish habitats in both inside and outside of the two selected embankments/ regulators. The survey was conducted for two years (2003-2004, 2004-2005).

Catch assessment survey of each habitat (Khal, inundated paddy field, irrigation canal, floodplain, river etc.) of open water fisheries both inside and outside of MDIP was performed. Habitats of inside of the embankment were inundated paddy field, khal, irrigation canal and the habitats of the outside of the embankment were khal, floodplain and rivers. At least 10% area from each habitat of both inside and outside of the embankment was selected for catch assessment survey. The survey was carried out fortnightly in each habitat and monthly gear-wise catch data was estimated for each habitat. Two types of questionnaires were used for the survey. Firstly, the total fishing unit of each gear was counted in the selected fishing habitat as per proforma of the questionnaire. Then another questionnaire was used for the fishermen in each selected fishing habitat. Gear-wise data were collected from the each sample unit. The number of sample unit for each type of gear was followed according to DOF Catch Assessment Manual (BFRSS 1990). One sample unit consisted of single gear, one boat (when present) and single or more than one fisherman. The number of sample units depended on the number of operated units and these were as follows:

Number of operated unit	Number of sample unit
1	1
2-4	2
5-9	3
10 and above	5

Gear-wise and group-wise monthly estimated catch was determined by using the Calculation Sheet of Monthly Estimated Catch.

The estimated daily catch was found by multiplying the average daily catch and the average operated unit. Thus the estimated monthly catch was found by multiplying the estimated daily catch and the number of fishing days.

Statistical analysis: Statistical analysis was done to find the significant difference between the monthly estimated catch of the same habitat of equal sample area of inside and outside the embankment. Mainly t-test (independent and paired t-test) is done for significant test.

Results and Discussion

Habitat-wise inland open water fish production / catch: In inside the embankment of MDIP, it was observed that the production / catch in irrigation canal was 13.90 kg / ha, khal (24.32 kg/ha), inundated paddy field / flood plain (1.99 kg/ha) in 2003-2004. But in outside the embankment the production / catch in khal was 531.56 kg / ha, floodplain (38.18 kg/ha), Megna river (137.87 kg/ha) and Dhonagoda river (124 kg/ha) in the same study period (Fig.1 and Table 1).

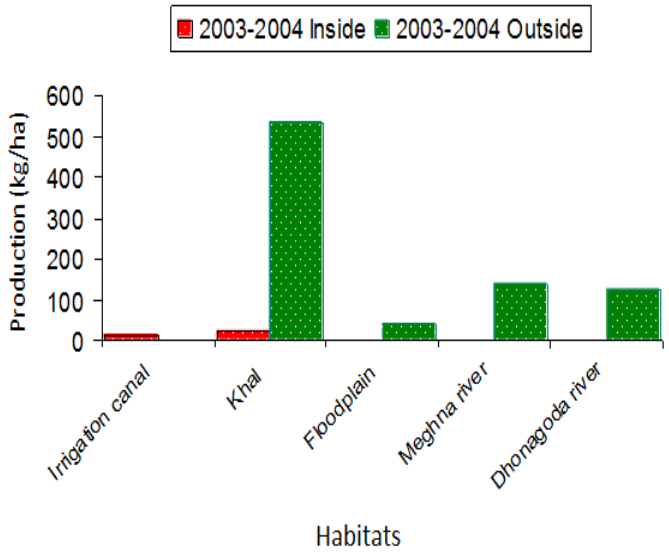

Fig.1. Habitat-wise catch / production both inside and outside of MDIP in 2003-2004.

From Fig. 2 and Table 2, it is apparent that the production/catch of inland open water such as, in irrigation canal was 21.94 kg/ha, khal (26.45 kg / ha), inundated paddy field (2.24 kg / ha) in 2004-2005.On the other hand , the production/catch of the outside habitats such as in khal was 528.77 kg / ha, floodplain (33.84 kg / ha), Meghna river (96.27 kg / ha), Dhonagoda river (85.92 kg / ha).

Table 1. Habitat- wise production of fish (catch of open water fisheries) in inside and outside of MDIP during April, 2003-March, 2004.

SL No.	Name of the fish habitat	Position of the fish habitat	Area of sample size (ha)	Total production or catch (kg)	Production (kg/ha)
1	Irrigation canal	Inside the embankment	5.97	83	13.90
2	Khal	Inside the embankment	20.23	492	24.32
3	Inundated paddy field (Floodplain)	Inside the embankment	180.16	359	1.99
4	Khal	Outside the embankment	3.58	1903	531.56
5	Floodplain	Outside the embankment	48.58	1855	38.18
6	Meghna river	Outside the embankment	322.29	44435	137.87
7	Dhonagoda river	Outside the embankment	228.29	28490	124.80

In both the years, the highest production of inside habitats was in khal, followed by irrigation canal and inundated paddy field / floodplain. In case of outside habitats, the highest production was in khal, followed by Meghnariver, Dhonagoda river and floodplain during both years of study.

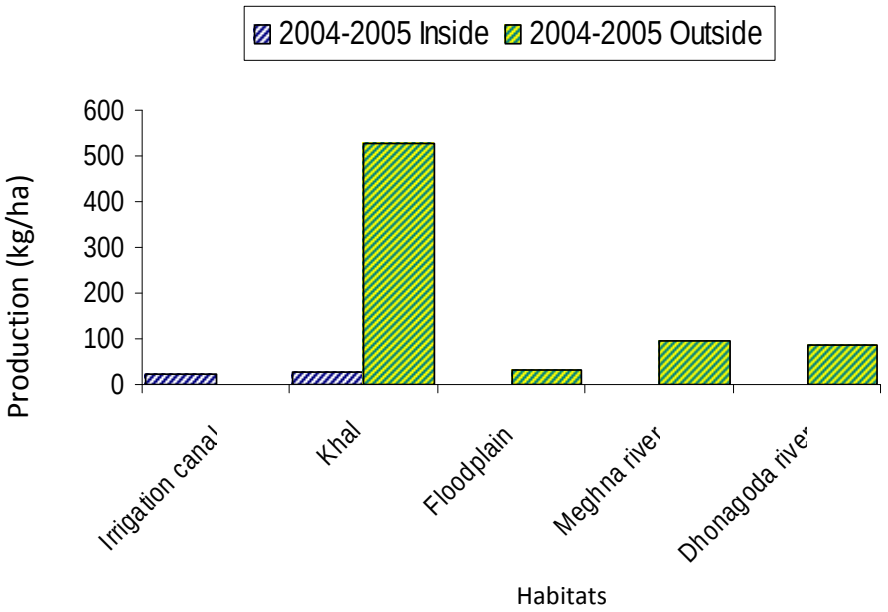

Fig. 2. Habitat-wise catch / production both inside and outside of MDIP in 2004-2005.

Table 2. Habitat- wise production of fish (catch of open water fisheries) in inside and outside of MDIP during April, 2004-March, 2005.

SL No.	Name of the fish habitat	Position of the fish habitat	Area of sample size (ha)	Total production or catch (kg)	Production (kg/ha)
1	Irrigation canal	Inside the embankment	5.97	131	21.94
2	Khal	Inside the embankment	20.23	535	26.45
3	Inundated paddy field(Floodplain)	Inside the embankment	180.16	404	2.24
4	Khal	Outside the embankment	3.58	1893	528.77
5	Floodplain	Outside the embankment	48.58	1644	33.84
6	Meghna river	Outside the embankment	322.29	31026	96.27
7	Dhonagoda river	Outside the embankment	228.29	19614	85.92

Monthly estimated catch

(a) Khal (inside) : Fig.3 shows that a total of 492 kg of fish was caught in different months throughout the year (2003-2004) by different types of gears. In September, the highest quantity of 159 kg of fish was caught, followed by August, 105 kg of fish, October, 97 kg of fish, July, 69 kg of fish and June, 53 kg of fish respectively (Fig. 3).

In 2004-2005, Fig.3 shows that a total of 535 kg of fish was caught in different months of the year by different types of gear. In September, the highest quantity of 328 kg of fish was caught, followed by October, 77 kg of fish, August, 72 kg of fish, July, 36 kg of fish and June 17 kg of fish respectively (Fig.3). It was also observed that the total catch was 492 kg in the inside khal in 2003-2004, whereas, the total catch was 535 kg in 2004-2005 in the same area, which was slightly higher than the previous year, In both years, the highest catch was in the month of September and in this month, the catch was more than double in 2004-2005 than 2003-2004 (Fig.3).

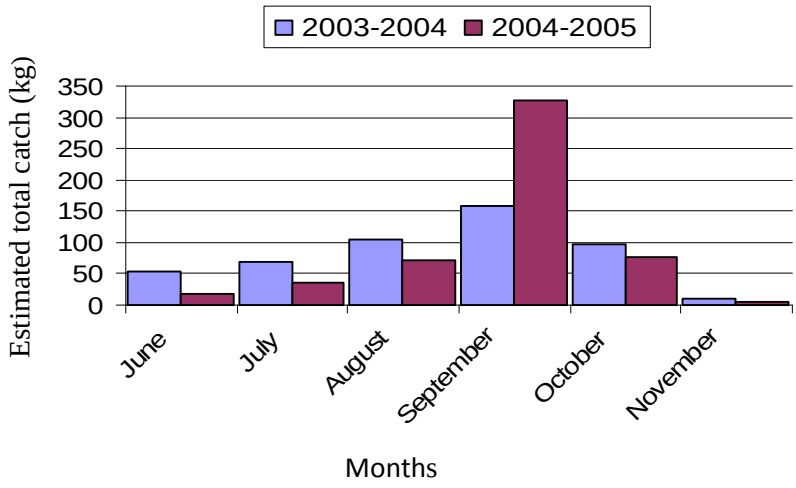

Fig. 3.Monthly estimated catch of khal (inside) of MDIP in 2003-2004 and 2004-2005.

(b) Irrigation canal (inside) : Fig.4 shows that a total of 83 kg of fish was caught in different months during the period of 2003-2004 by different types of gears. In July, the highest quantity of 24 kg of fish was caught, followed by September, 20 kg of fish, August, 14 kg of fish, June, 13 kg of fish respectively (Fig. 4).

In 2004-2005, Fig. 4 shows that a total of 131 kg of fish was caught in different months of the year by different types of gears. In September, the highest quantity of 85 kg of fish was caught, followed by July, 13 kg of fish, June, 12 kg of fish , August, 10 kg of fish and 4 kg of fish respectively (Fig.4).

It was also noted that the total catch was 83 kg in irrigation canal in 2003-2004, while, the total catch was 131 kg in 2004-2005 in the same area which was comparatively higher than 2003-2004. During 2004-2005, the maximum catch was in the month of September but more or less equal and highest catch was in the months of July and September in 2003-2004 (Fig.4). The highest catch in the month of September in 2004-2005 was four times higher than the highest catch in the month of July or September in 2003-2004.

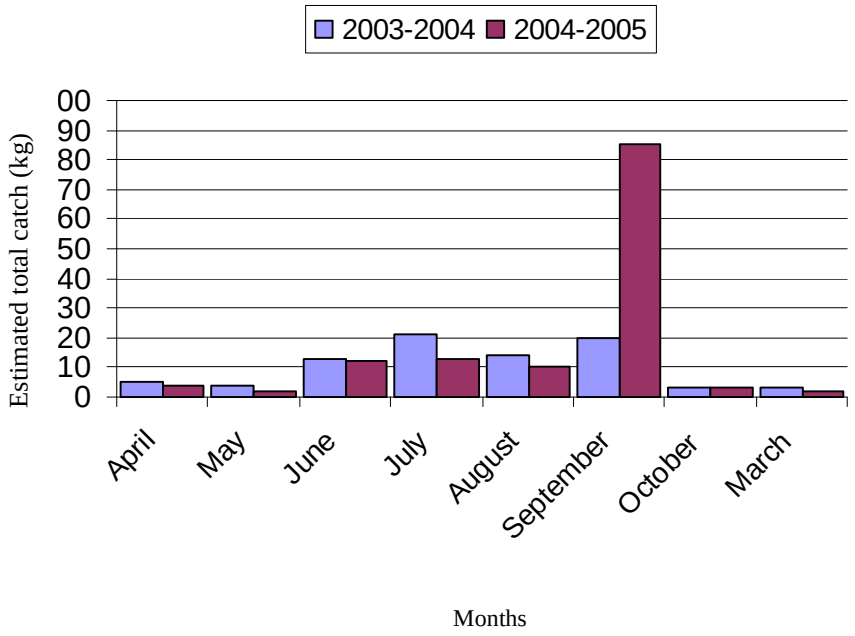

Fig. 4. Monthly estimated catch of Irrigation canal (inside) of MDIP in 2003-2004 and 2004-2005.

(c) Khal (outside) : Fig. 5 illustrates that a total of 1903 kg of fish was caught in different months during the period of 2003-2004 by various sorts of gears. In the month of October, the highest quantity of 859 kg of fish was caught, followed by September, 454 kg, August, 269 kg, July, 143 kg, November, 81 kg , December, 47 kg correspondingly (Fig. 5). For the duration of 2004-2005, Fig. 5 shows that a total of 1893 kg of fish was caught in different months of the year by various kinds of gears. In October, the highest quantity (697 kg) of fish was caught, the second highest was 678 kg , after that 238 kg in August, 122 kg in July and 63 kg in November respectively (Fig. 5).

It was also found that the total catch was 1903 kg in outside khal in 2003-2004 which remained nearly unchanged in 2004-2005 with 1893 kg.

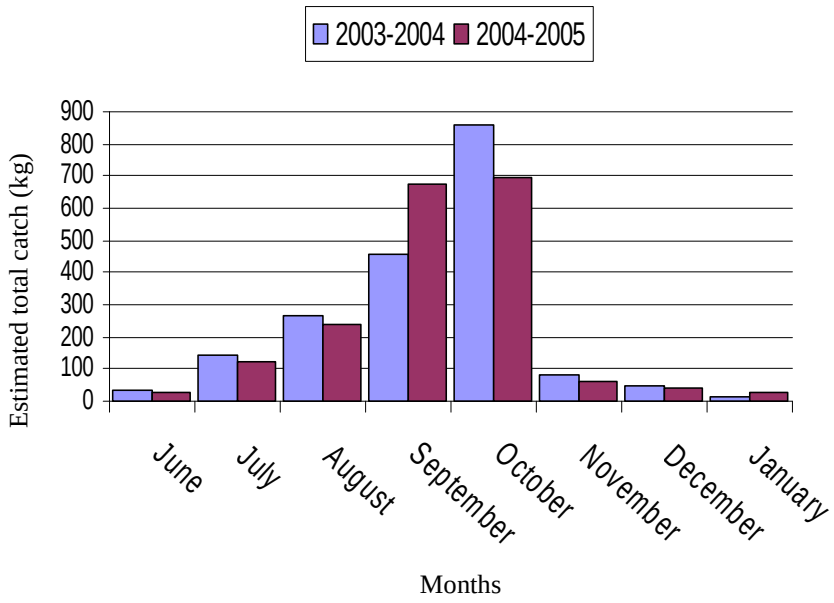

Fig. 5. Monthly estimated catch of khal (outside) of MDIP in 2003-2004 and 2004-2005.

(d) *Inundated paddy field / floodplain (inside)* : Fig.6 shows that a total of 359 kg of fish was caught in different months throughout the year (2003-2004) by different sorts of gears. The highest quantity of 183 kg of fish was caught in August, after that 169 kg in July and 7 kg in September (Fig. 6).

It was also observed that total catch was 359 kg in the inundated paddy field / floodplain inside during 2003-2004, where, the total catch was 404 kg in 2004-2005 in the same area, which was higher than the foregoing year.

In 2003-2004, the highest catch was in the month of August, where it was in the month of September in 2004-2005. But the lowest catch (7 kg) was in September during 2003-2004.

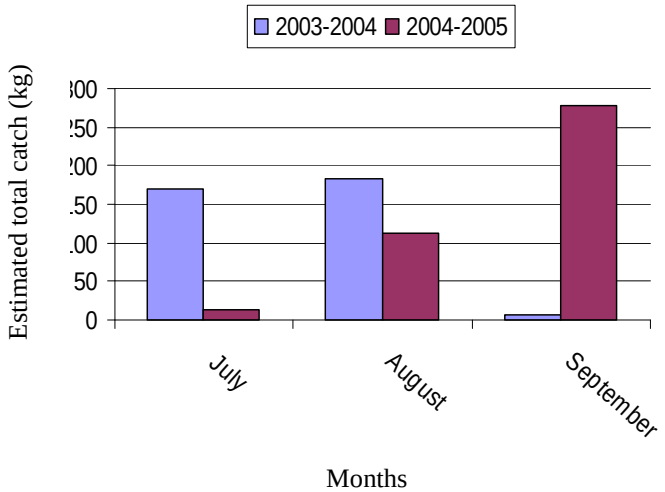

Fig. 6. Monthly estimated catch of inundated paddy field (inside) of MDIP in 2003-2004 and 2004-2005.

(f) Floodplain (outside) : Fig. 7 shows that a total of 1855 kg of fish was caught in different months during 2003-2004 by different kinds of gears. In the month of August, the highest quantity of 735 kg of fish was caught, followed by September, 577 kg, July, 488 kg and October, 55 kg respectively (Fig. 7). In 2004-2005, Fig. 7 shows that a total of 1644 kg of fish was caught in different months by various types of gears. In September, the highest quantity of 744 kg of fish was caught, followed by 506 kg in August, 349 kg in July and 45 kg in October correspondingly (Fig. 7.). It was also found that the total catch 1855 kg in outside floodplain in 2003-2004 was higher than the total catch (1644 kg) in 2004-2005 in the same area.

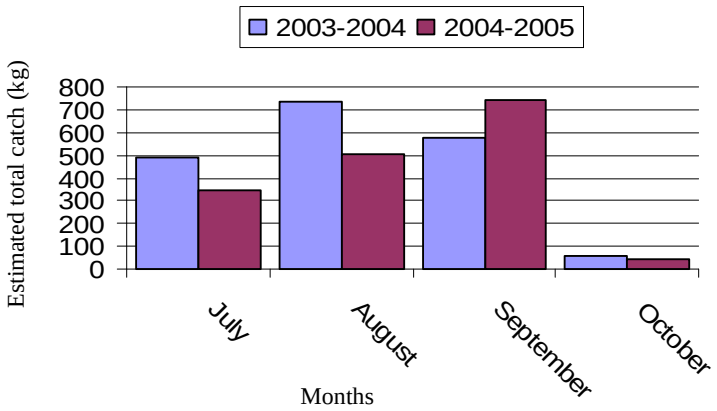

Fig.7. Monthly estimated catch of floodplain (outside) of MDIP in 2003-2004 and 2004-2005.

(g) Meghna river (outside) : In 2003-2004, the highest monthly estimated catch was found 8311 kg in the month of April, followed by 5478 kg in May, 4631 kg in August, 4434 kg in September,4170 kg in July, 3760 kg in October, 3001 kg in February, 2956 kg in March and the lowest catch was 1182 kg in December, where, in 2004-2005, the highest catch was 3977 kg in August, followed by 3866 kg in July, 3597 kg in April, 3452 kg in September, 2621 kg in October, 2515 kg in March, 2427 kg in May, 2399 kg in June, 2124 kg in February and the lowest catch was 1115 kg in December in the same area (Fig. 8)

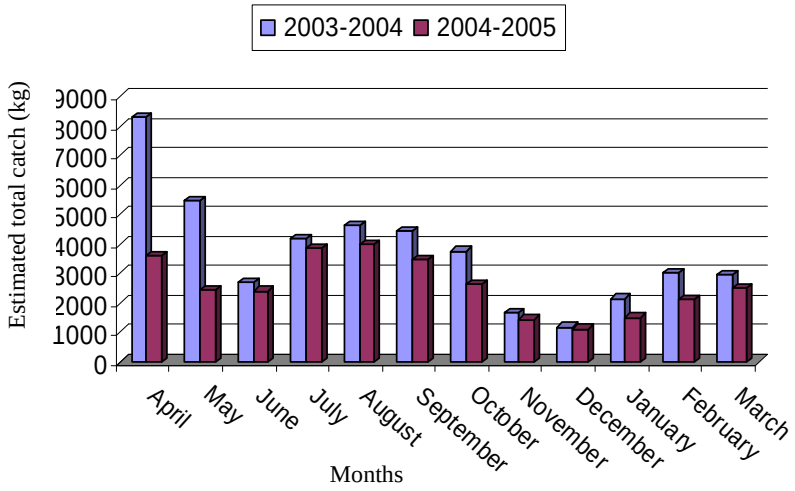

Fig. 8. Monthly estimated catch of Meghna river (outside) of MDIP in 2003-2004 and 2004- 2005.

(h) Dhonagoda river (outside): During the period of 2003-2004, it was observed that the highest monthly estimated catch was 4336 kg in April, followed by 3033 kg in February, 2964 kg in March, 2946 kg in May, 2781 kg in October, 2600 kg in December, 2342 kg in November and the lowest was 1200 kg in July respectively (Fig. 9). On the other hand, the highest catch was 2481 kg in October; followed by 2104 kg in March, 2096 kg in December, 1990 kg in February, 1950 kg in November and the lowest 688 kg was in April in 2004-2005.

The estimated catches were very high in floodplain, outside the embankment, in compare to inside inundated paddy field / floodplain. It is obvious that in all cases, the catches were always higher in the outside habitats of inland open water habitats than the same of the inside, which is the negative impact of the construction of the embankment. The natural fishes cannot enter into the inside habitats from the river due to the obstruction of the movement of fishes. This findings are similar to the study of PIRDP where it was found that low catch rates in the inside FCDI schemes (Halls 1998 and Halls *et al*. 1999).

MRAG (1997) found the productivity, measured as catch per unit area, outside the Bangladesh FCDI scheme (104 and 130 kg/ha/yr in 1995 and 1996 respectively), was significantly higher than inside (51 and 81 kg/ha/yr). Although it was far away from the present findings but when the present findings are compared between the production of inside and outside it reveals that the outside floodplain production is also significantly higher than the inside production . So, it is evident that the result of MRAG is in conformity with the present findings.

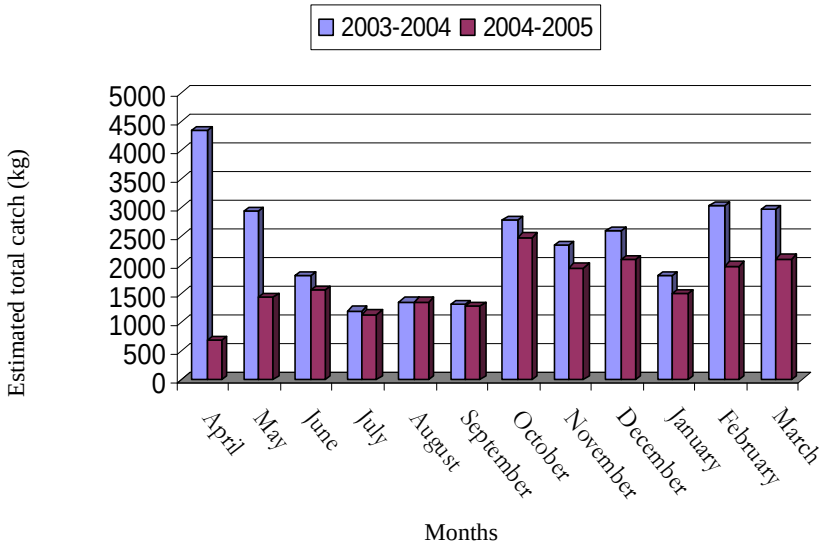

Fig. 9. Monthly estimated catch of Dhonagoda river (outside) of MDIP in 2003-2004 and 2004-2005.

Farmers used to catch wild fish from rice fields and some estimates put these harvests at 37 kg / ha (MPO 1985). But in inundated paddy field, this production was found only 2.24 kg / ha which is lower than the statement of MPO (1985) indicating the negative impact of embankment on capture fisheries in floodplains / inundated paddy field.

Statistical analysis was done between monthly estimated catch of inundated paddy field (inside) and floodplain (outside), between khal (inside) and khal (outside), between irrigation canal (inside) and khal (outside) of equal area and it was found that statistically significant at 0.05 level ($p<0.05$) in both the years.

From two years of study, it is also evident that in Meghna and Dhonagoda river, the trends of estimated catch was diminishing in 2004-2005 than in 2003-2004. This might be due to the unavailability of fishes in the rivers adjacent to the embankment having blockage of the migration route, over fishing, implementation of the Fish Act mainly for Jatka control from the year 2004 during the months of January to May.

References

Ali, S. M. I. and M. I. W. Zaman. 1989. Some aspects of environmental degradation of the inland open water fisheries of Bangladesh.Darjeeling University.20 pp.

BBS, 2001. Report of Household Income and Expenditure Survey 2001. Bangladesh Bureau of Statistics, Dhaka. 16 pp.

BCAS, 1991. Floodplain production monitoring--- initial study report. Bangladesh Centre for Advanced Studies, Dhaka. 99 pp.

BFRSS, 1990. Manual of Catch Assessment Survey (Revised). DOF.MOFL. Dhaka:122pp.

BFRSS, 1983-84. Fish Catch Statistics of Bangladesh. DOF.1983-84.

BFRSS, 2003-2004. Fishery Statistical Yearbook of Bangladesh. DOF. 41p.

DOF, 1995. Project proforma. Third Fisheries Project. Department of Fisheries, Government of the People's Republic of Bangladesh. 118pp.

DOF,1999. Brochure on Fish Week. Department of Fisheries, Bangladesh, Dhaka. 1999. 110pp.

DOF, 2001. Aquatic Resources Development, Management and Conservation Studies. Inception Report. Global Environmental Facility / World Bank. Goverment of the People's Republic of Bangladesh. Department of Fisheries. December 2001. 14 pp.

DOF, 2005. Brochure on Fish Fortnight. National Fish Fortnight-2005. Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh. 112p.

DOF, 2016. Brochure on National Fish Week 2016.Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh. 148pp.

FAP-12, 1992b. Project impact evaluation of Meghna- Dhonagoda Irrigation Project. FCD/I Agricultural Study FAP. Hunting Technical Services Ltd, February 1992. pp.175.

FAP- 17 (Flood Action Plan). 1995. Final Report- Main Volume. Overseas Development Administration, UK. pp. 145

FAO, 1997. Aquaculture Development. FAO Technical Guidelines for Responsible Fisheries No. 5. Rome. 58pp.

Halls, A. S. 1998. An assessment of the impact of hydraulic engineering on floodplain fisheries and species assemblages in Bangladesh. Ph.D. thesis, University of London, 526 pp.

Halls, A. S., D. D. Hoggarth, and D. Debnath. 1999. Impacts of hydraulic engineering on the dynamics and production potential of floodplain fish populations in Bangladesh. Fisheries Management and Ecology. **6**(4): 261-285.

Halls, A. S., D. D. Hoggarth, and K. Debnath. 2000. Impacts of hydraulic engineering on the dynamics and production potential of floodplain fish populations in Bangladesh: implications for management. In: I.G. Cowx (eds.) Management and Ecology of River Fisheries. Oxford: Fishing News Books, Blackwell Science, pp. 201-217.

Hossain, M. 1998. A preliminary survey on the fisheries and socio-economic conditions of fishermen of the Old Bramaputra river . M. Sc. Thesis, Department of Fisheries Management . BAU, Mymensingh. 95 pp.

MPO (Master Plan Organization). 1985. Open water capture fishery resources. Ministry of Irrigation, Water Development and Flood Control.Tech. Rep. No. **16**. 34 pp.

Mazid, M. A. and M. S. Hossain. 1995. Development of fisheries resources in floodplains. FRI publication no.12. Fisheries Research Institute, Mymensingh, Bangladesh (In Bangla), 16 pp

MRAG, 1997. Fisheries Dynamics of Modified Floodplains in Southern Asia. Final Technical Report. London: MRAG, 275pp.

Nishat, A. and M. A. Bhuiyan. 1995. Strategy for Integrated Management of Land and Water in FCDI Projects with Focus on Fisheries Development. pp.139-156. In: Report of the National Workshop on Fisheries Resources Development and Management in Bangladesh. Dhaka, Bangladesh. 302 pp.

(Revised copy received on 29-8-2017)