# Evaluation of Environmental Impacts of Ship Recycling In Bangaldesh

# Final Report

**For**

**INTERNATIONAL MARITIME ORGANIZATION**

**Programme No. TC/1514**

**“SENSREC”**

**Safe and environmentally sound ship recycling in Bangladesh – Phase I**

**December 2016**


Photo: Roy Watkinson

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**INTERNATIONAL MARITIME ORGANIZATION**

**Programme No. TC/1514**

**“SENSREC”**

# Safe and environmentally sound ship recycling in Bangladesh – Phase I

**Activity No. 1**

## Environmental impact of ship recycling industry in Bangladesh

**(Work package 1, Study Component 2)**

**WBS Element No. TC/1514-01-2320**


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## Acknowledgements

The authors and editor wish to gratefully acknowledge the assistance given to them by many contributors whose assistance has enabled the development of this report. In particular the Ministry of Industries, especially Mrs Yasmin Sultana and Mr Mizanur Rahman; and the Department of the Environment of the Ministry of Environment and Forests, of the Government of Bangladesh; the Bangladesh Ship Breakers Association and their members who facilitated field visits; Dr Nikos Mikelis and staff of the International Maritime Organisation as well as stakeholders and others, including Professor Maruf Hossain, who have contributed their time and expertise.

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## Glossary of terms and abbreviations

| | |
|---|---|
| **BRS** | Secretariat of the Basel, Rotterdam and Stockholm Conventions |
| **BOD** | Biochemical Oxygen Demand |
| **BSBA** | Bangladesh Ship Breakers Association |
| **COD** | Chemical Oxygen Demand |
| **CU** | Chittagong University, Bangladesh |
| **DO** | Dissolved Oxygen |
| **DoE** | Department of Environment, Ministry of Environment and Forests, Bangladesh |
| **DoF** | Department of Fisheries, Ministry of Fisheries and Livestock, Government of Bangladesh |
| **EC** | Electrical Conductivity |
| **ECR** | Environmental Conservation Rules, Bangladesh 1997 |
| **EIA** | Environmental Impact Assessment |
| **ETP** | Effluent Treatment Plant |
| **HKC** | Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, May 2009 |
| **IMO** | International Maritime Organization |
| **MoEF** | Ministry of Environment and Forests Government of Bangladesh |
| **MoI** | Ministry of Industries, Government of Bangladesh |
| **NGO** | Non-governmental organization |
| **PCB** | Poly-Chlorinated Biphenyls |
| **PM** | Particulate Matter, maybe qualified according to size, e.g. PM10=particulate matter less than 10micrometres in size |
| **PAH** | Polycyclic Aromatic Hydrocarbons |
| **POPs** | Persistent Organic Pollutants |
| **SBRI** | Ship Breaking and Recycling Industry |
| **SME** | Small and Medium-sized Enterprises |
| **SPM** | Suspended Particulate Matter |
| **SRDI** | Soil Resources Development Institute, Ministry of Agriculture, Dhaka |
| **TBT** | Tributyl Tin – antifouling agent |
| **TDS** | Total Dissolved Solids |
| **USD** | United States Dollars |
| **YPSA** | Young People in Social Action |

**Executive Summary**

This report comprises two Parts: Part 1 describes the purpose and approach taken to assessing the environmental conditions which prevail at and around the ship recycling area at Sitakunda, Chittagong, Bangladesh in order to provide a baseline understanding of the environmental factors affecting this area. Part 2 describes in some more detail an assessment of the environmental impact of ship recycling in the form of an Environmental Impact Analysis. This is not complete as it is not expected that this assessment would constitute a full formal Strategic Environmental Assessment or an Environmental Impact Assessment, which would require a more detailed study. Some aspects are covered in greater depth in other elements of the SENSREC project as a whole and are outside of the scope of this report, and some data are lacking. Information gaps that need to be filled are discussed. Information has nevertheless been obtained through literature survey, investigation and field work undertaken in connection with this report to establish the main features of the environmental system under examination.

Ship recycling at Sitakunda, Bangladesh, sits within a complex zone of marine coastal, urban and rural land-based environments. There are major river discharges (from the Karnaphuli, the Feni and the Sangu) into the Bay of Bengal close to the ship recycling zone and tidal influences on the shoreline. The river and other water systems, canals, streams and direct discharges of sewage from residential, commercial and industrial sources all make inputs to the Bay. Mangrove clearance has been carried out (as reported from Landsat[1] imagery studies) and will have affected the ecology, including the distribution of flora and fauna in the area. Ship recycling is not therefore an isolated activity. These other inputs will have their own impact on the local environment and should be distinguished from those for which ship recycling itself is likely responsible. Reports providing a comprehensive overview of the state of the environment in this area have not been found. Topics that require further elaboration on the environmental status of the ship recycling area include: the geographical context, hydrography, sediment, marine ecology pollution impacts, designated environmental zones and environmental monitoring.

The ship recycling yards are located in the Sitakund coast, along the northern part of Chittagong district. The Dhaka-Chittagong highway (known as the Asian highway) and the railway pass through this area. The total area supports hilly streams, Sandwip channel, accreted mud flats, wet meadows, mangrove ecosystem, plain land, hills and hillocks. The upland area is used for cultivation and human settlement. The hill bottom alluvial land system extends up to the tidal alluvial land and the Sandwip Channel.

The streams from the nearby hilly region run through heavy industrial areas (such as cement, glass, steel and re-rolling, jute, textile, pharmaceutical, automobiles, that typically generate heavy metals, oil, acids, alkalis, ammonia, dyeing agents, drug disposal chemicals, detergent, antibiotics, organic and inorganic wastes, etc.) and ultimately empty

[1] Abdullah HM, Mahboob MG, Banu MR, Seker DZ., 2013. Monitoring the drastic growth of ship breaking yards in Sitakunda: a threat to the coastal environment of Bangladesh. Environmental Monitoring and Assessment 185(5): 3839–3851.

into the Bay of Bengal, where the ship recycling yards are also located. Intensified agriculture runoff and domestic sewage are also of potential concern. Considering all these issues, drawing a clear picture of the pollutants from ship recycling activities alone would be difficult without conducting a thorough pollutant profiling investigation, which was beyond the scope of this study. Nevertheless:

- Studies have shown that while marine waters and sediments at Sitakunda are contaminated with a range of substances (pollutants including heavy metals, oil, PCBs, agro-chemicals and sewage) the parameters investigated (metals, BOD, TDS) do not appear to be greatly exceeding reference values, in some but not all studies, – the reasons for this are unclear and could be due to any or all of factors relating to: low release, mixing, dispersion and sampling location and timing (to take account of the effect of seasonal weather fluctuations especially rainfall);

- The composition and quantity of pollutants from point and non-point sources (other than ship recycling), their distribution in natural systems and impacts also need to be fully studied;

- Further knowledge of the effects on biota is required to be able to verify/substantiate such observations.

It has been alleged that 10 different coastal fish species have disappeared, and 21 species are under threat and occurring rarely in the Sitakunda area due to environmental damage caused by ship recycling activity[2]. This claim needs to be validated through scientific study to take account of other potential causes, such as fish take. For example, during the field visits carried out as part of this study, stake fish nets and fry catching nets were observed in the vicinity of the ships, indicating that fishing activities are an ongoing practice at subsistence level.

Some water parameters (pH, EC, TDS, Chloride, dissolved oxygen, COD, oil and grease, and $NH_3$) and ambient air (SPM, $SO_x$, $NO_x$ and sound level) quality data are now routinely monitored by the DoE. But heavy metals, PCBs, PAH and biological samples (e.g. aquatic biodiversity) also need to be routinely monitored in a regular and consistent manner.

Studies such as modelling, comparative analysis of pollutant profiles from the range of inputs from all industries into the Bay and their transport, together with contour maps of plumes and dispersal calculations would lead to more definitive understanding of the sources of the contaminants.

From this study it has been evident that many variables for a robust understanding of the impacts of the ship recycling industry on the environment are unknown. These variables include, for example, concentrations and species variations of pollutants in different sub-

[2]The Daily Star (2010b) Ship breaking yard pollution threatens extinction of hilsa. http://www.thedailystar.net/news-detail-132782, retrieved 23/05/2016.

systems, land-use change, segregation of pollution load from other (non-ship recycling) activities, biodiversity of the area, local oceanography, water current and circulation, discharge through streams and canals etc. Further studies are therefore needed by means of a carefully designed, broader, systematic investigation of these aspects of the environment in this area.

Bangladesh has a well-developed set of environmental policies, Acts and Rules that deal with industrial pollution of water, soil and air. In recent years, a number of the ship recycling yards have invested in upgrades to their facilities. Waste treatment facilities including oil-water separator, incinerator, and sewage tanks are in the process of being established. It is hoped that an environment monitoring laboratory and a landfill site will also be established in the near future.

Recommendations are made for:

- An improved understanding of the environmental context of the ship recycling area at Sitakunda, in terms of the coastal marine and land environment, to be able to fully appreciate its potential impacts in comparison with other possible inputs from industry re-fabrication, recycling and distribution as well as settlements and agriculture;
- Additional study of the range and distribution of biota over time, particularly to identify useful indicator species and those of local and commercial importance, including fish, shrimp, crab, mollusc, and coastal plants (mangroves) species;
- An improved understanding of the separate contribution to environmental pollution made by other industry, agriculture etc. to be able to differentiate this from ship recycling per se, especially where the same substances maybe being released (e.g. heavy metals, oils and grease, paints);
- Further development of monitoring programmes for environmental pollution with establishment of time series measurements, helping to elucidate the causes and better assess mitigation efforts;
- A “Shipyard zone” demarcated in the coastal environment, limiting the activities within a certain area to assist in considering potential environmental impacts and regulatory mechanism;
- Development of laboratory facilities for environmental monitoring to assist in progressing these aims.

The above are needed to enable a comprehensive Environmental Impact Assessment to be produced and, as indicated in summary in the EIA produced as part of this report, assist in identifying the range of measures (beyond any already in place) that could be employed to manage any potentially polluting emissions such as how releases to the environment from ship recycling can be reduced with the installation of further treatment plant for ship breaking and recycling (such as oil-water separators, incinerator, hazardous waste treatment plant (TSDF)) as well as engineered landfill sites for treated materials.

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## PART 1: OVERVIEW OF REPORT - PURPOSE AND APPROACH

### 1 Introduction

Ship recycling has been carried out in Bangladesh for more than 30 years and the activity has significant economic importance in terms of supplying raw materials to the steel mills, developing small and medium-sized enterprises (SMEs) as well as creating jobs for local people. This section deals with the general picture of the environment around the ship recycling area at Sitakunda (Chittagong) including the project goal, aimed at illustrating an environmental impact study of the ship recycling activity.

### 1.1 Background context

The Safe and Environmentally Sound Ship Recycling (SENSREC) project in Bangladesh is designed to enhance the development of safe and environmentally sound ship recycling in Chittagong, Bangladesh. The objective of the project as a whole is to make the ship recycling industry sustainable in the future by helping it improve its occupational safety and health working conditions and the protection of the environment[3]. The overall project is led by the Ministry of Industries of the Government of Bangladesh with technical support from the International Maritime Organization (IMO) and project funding from the Norwegian Agency for Development Cooperation (NORAD).

Ship recycling at Sitakunda, approximately 20 km northwest of Chittagong city, is situated within a complex zone of marine, coastal, urban and rural land-based environments. This activity began in the 1960s and has since represented a considerable share of the world market of ship recycling. During 1980s, there were 30 companies involved in the ship recycling industry and the number has grown to more than 100 in recent years. Ship recycling activities taking place here represent the second/third largest facility in the world with respect to the numbers of vessels being recycled due to higher tidal range (up to 4 m in spring tide), suitable intertidal zone for beaching large vessels, cheap labour and slack environmental regulations[4,5]. In 2014, a total of 22.76 million Gross Tons (GT) was recycled in the world. India was the biggest ship recycler with 6.79 million GT (29.8%), Bangladesh came second with 5.52 million GT (24.2%), China was third with 4.98 million GT (21.9%), Pakistan fourth with 4.09 million GT (18.0%) and Turkey fifth with 0.98 million GT (4.3%). That left only 0.40 million GT (1.8%) for the rest of the world[6].In 2015, the world total was 21.80 million GT. Bangladesh was the biggest ship recycler with 7.52 million GT (34.5%), Pakistan came second with 4.59 million GT (21.1%), India was third with 4.56 million GT (20.9%), China fourth with 4.04 million GT (18.5%) and Turkey fifth with 0.75 million GT (3.4%). Again, that left only 0.34 million GT (1.6%) for the rest of the world[7].

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[3]RWEC 2015, Safe and environmentally sound ship recycling in Bangladesh Phase 1 - Scoping Study Report for International Maritime Organization, Roy Watkinson Environmental Consulting Ltd, RWEC/03/TC/1514-01-2320, 77 pp.

[4]Hossain, M.S, Chowdhury, S.R, Jabbar, S.M.A, Saifullah. S.M, Rahman. M.A., 2008. Occupational Health Hazards of Ship Scraping Workers at Chittagong Coastal Zone, Bangladesh. *Chiang Mai Journal of Science*. 35(2): 370-381.

[5]Alam S, Faruque A, 2014. Legal regulation of the shipbreaking industry in Bangladesh: The international regulatory framework and domestic implementation challenges. Marine Policy 47: 46-56.

[6]World Casualty Statistics 2014, Published by IHS Global Limited

[7] World Casualty Statistics 2015, Published by IHS Global Limited

Ship recycling is a challenging process, due to the structural complexity of the ships and the involvement of environmental, safety, and health issues[8]. Although steel is recycled, any uncontained toxic substances released contaminate the environment. The coastal ecosystems including beach, surface and ground water, biodiversity, workers and local community, and air quality are at risk during this process.

Ship recycling by the beaching method has been carried out in Bangladesh for more than 30 years. Ship recycling now reportedly provides employment for some 22,000-50,000 people directly and some 100,000-200,000 (reported range of World Bank[9]/YPSA[10]) people indirectly. It has been reported that large amounts of hazardous materials are likely to accumulate in Bangladesh if the prevailing practices continue over the next 20 years. Incidence of much higher concentration of metal pollutants in sediments of Sitakunda was due to the presence of ship recycling yards[11].

Tidal streams are important local mechanisms of water, nutrient and pollutant movement. Tides are semi-diurnal, showing two high and two low waters during a lunar day. Tidal behaviour varies along the coast in terms of magnitude but not of pattern. The tidal range at the head of the Bay of Bengal is strong, ranging from 4.27 m at neap tides to about 6.10 m at spring tides, observed in the Sandwip area (Satalkhal). At Sadarghat, Chittagong, monthly mean tidal range varies from 1.48 to 4.90 m with a 24 year average of 3.84 m[12] (Figure 1.1).The coast is dominated by soft substrate ecosystems, leading to a highly sedimentary environment, encouraging growth of salt marshes, mangroves and algal beds. Each year about 2.4 billion tons of sediment are transported by the Ganges-Brahmaputra-Meghna river systems, some of this tremendous amount of silt is deposited on the shore, causing land accretion and forwarding the coastline towards the sea, particularly in the central and southeast coastal region.

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[8] ILO (International Labour Organization), 2004. Safety and health in ship breaking, Guidelines for Asian Countries and Turkey.

[9] The Ship Breaking and Recycling Industry in Bangladesh and Pakistan, World Bank Report No 58275-SA, Dec 2010

[10]http://www.shipbreakingbd.info/overview.html, May 2015.

[11]Aktaruzzaman M, Chowdhury MA, Fardous Z, Alam K, Hossain MS, Fakhruddin ANM, 2014. Ecological risk posed by heavy metals contamination of ship breaking yards in Bangladesh. Int. J Environ Res 8:469-478.

[12]Chowdhury SR. Study on tidal behaviour along the coast of Bangladesh with special influences on the seasonal variation in the mean sea level. MSc Thesis, Institute of Marine Sciences, University of Chittagong, Bangladesh, 1992.

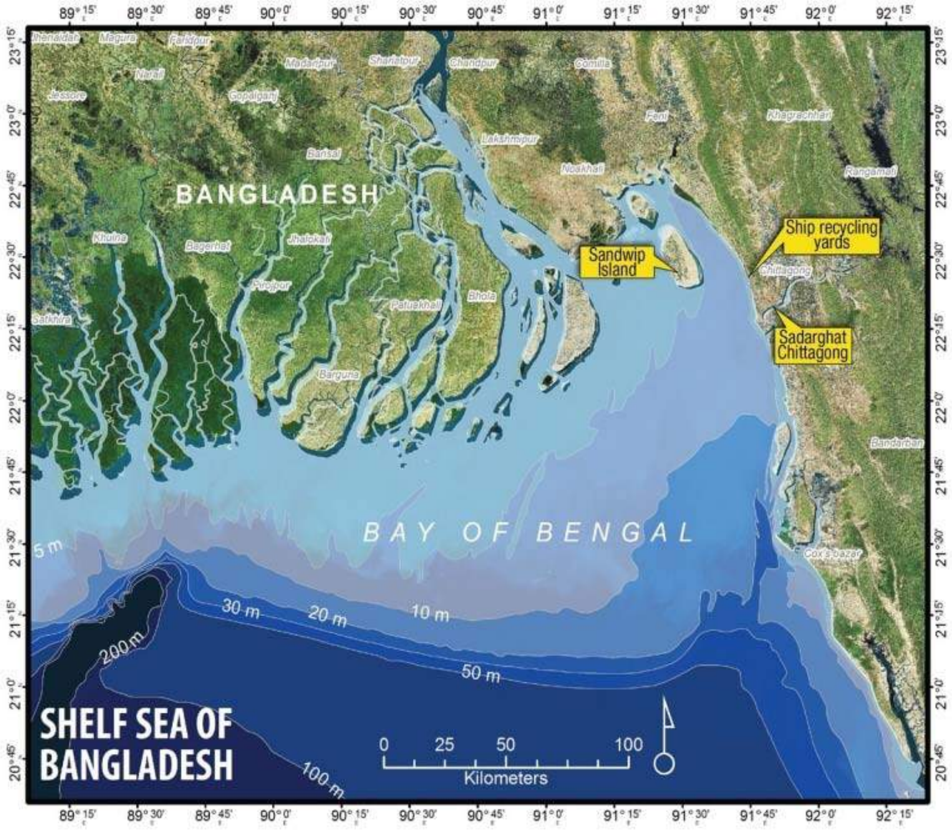


**Figure 1.1: Map showing shelf sea of Bangladesh (source: Sayedur R Chowdhury)**.

There are major river discharges (from the Meghna, Muhuri, Karnaphuli and the Sangu) into the Bay of Bengal close to the ship recycling zone and tidal influences on the shoreline. Moreover, 7 streams flow from the nearby upland areas associated with rural settlement, intensified agriculture and subsequent heavy industrial zones of the Sitakunda, which empty into the coastal water within and around the ship recycling yards. The river and streams carrying untreated sewage, industrial effluents, and agro-chemical residues all make inputs to the coastal water (Ahmed et al. 2010[13]; BOBLME 2011[14]; Sharifuzzaman et al. 2016[15]), (Figure 1.2). Mangrove clearance has been carried out to expand the ship recycling yards that destroyed feeding, breeding and nursery ground for various marine, estuarine and freshwater fishery resources and also affected the distribution of floral and faunal biodiversity in the area. However, ship recycling is not an isolated activity in the Sitakunda coastal area. These other inputs will have their own impact on the local environment and should be distinguished from those for which ship recycling itself is likely responsible.

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[13]Ahmed MJ, Haque MR, Ahsan A, Siraj S, Bhuiyan MHR, Bhattacharjee SC, Islam S, 2010. Physicochemical assessment of surface and groundwater quality of the greater Chittagong region of Bangladesh. Pakistan Journal of Analytical & Environmental Chemistry 11(2): 1-11.

[14]Bay of Bengal Large Marine Ecosystem (BOBLME) Project *(2011)* Country report on pollution in the BOBLME – Bangladesh. http://www.boblme.org/documentRepository/BOBLME-2011-Ecology-01.pdf, retrieved 26/05/2016

[15]Sharifuzzaman SM, Rahman H, Ashekuzzaman SM, Islam MM, Chowdhury SR, Hossain MS, 2016. Heavy metals accumulation in coastal sediments. pp. 21–42. *In:* Hasegawa H, Rahman IMM, Rahman MA (Eds.), Environmental Remediation Technologies for Metal-Contaminated Soils, Springer Japan, 254p.

Reports providing a comprehensive overview of the state of the environment in this area are not available. As a result, the scientific information regarding the quantity of pollutants and their extent of damage to water quality and natural resources remains largely unknown or incomplete.

**Figure 1.2: Discharge of industrial effluent from an upstream nearby ship recycling zone. On the right, a zoomed image for the waterbody displaying discolouration.**

## 1.2 Goal and objectives

The goal of this study is to prepare an environmental impact analysis with up-to-date environmental information of the ship recycling industry in Bangladesh. The specific objectives are:

a) to review available literature by taking into account the associated Scoping Study Report to provide an up-to-date picture of the environmental impact of ship recycling industry;
b) to identify local environmental pressures from other sources as well as their environmental impact;
c) to carry out field work (environmental sample collection and analysis) and stakeholder consultation in order to obtain additional data to fulfil identified information gaps;
d) to prepare a comprehensive environmental impact study report of the ship recycling industry.

## 2. Data gaps

### 2.1 Environmental context information

The primary focus of studies on the environment at and around the ship recycling yards has been mainly but not exclusively on the marine ecosystem. Coastal oceanographic processes, including sediment dynamics, water circulation pattern and monsoon effects are nonetheless not well understood, as there have been very limited published detailed scientific accounts of these aspects in this area. The dynamics of water exchange and suspended sediment flux are capable of influencing physicochemical water properties of any particular area (Nabi et al. 2011[16]). The water flux at Sitakunda coast during flood tide was higher than ebb tidal phase, which may be due to the piling-up of the content in the head of the Bay, which results in a rise in local sea level (Chowdhury 1993[17]).The discharge slows due to a time lag for return back to the sea caused through a long criss-crossed network of water bodies. Upward transport of sediment during flood tide was higher than discharges returning to the sea through the inlet, with ebb and flow during the measured tidal cycles resulting in a net gain of sediment. These sediment particles might settle onto the floor of the inlet basin as well as the adjacent coasts to accumulate in layers, gradually filling the inlet and up-lifting the nearby coasts if this trend continues (Nabi et al. 2011[16]).

Due to these factors, localized pollution that may occur, or is observed at ship recycling areas, could be changed both in terms of concentration and composition. However, information on the transport, mixing, dispersal and redistribution of pollutants in the area are unknown. From a general understanding of the longshore tidal current and the plume of the Karnaphuli River which injects its water southward into the bay, it is unlikely that the municipal pollutants from that river mix northwards to any extent with the wastes from ship recycling yards. Additionally, seven different streams from the nearby hilly region run through heavy industrial areas (such as steel and re-rolling mills, corrugated iron factories, inland container depots, cement factories, glass industries, automobile factory, pharmaceutical industry, textile industries, jute and carpet industries, and oxygen factory-that typically generate heavy metals, oil, acids, alkalis, ammonia, dyeing agents, drug disposal chemicals, detergent, antibiotics, organic and inorganic wastes, etc.) and ultimately empty into the Bay of Bengal, where the ship recycling yards are also located. Intensified agriculture runoff and domestic sewage are also of potential concern.

Considering all these issues, drawing a clear picture of the pollutants from ship recycling activities alone would be difficult without conducting a thorough pollutant profiling investigation, which was beyond the scope of this study. However, major pollutants from ship recycling activities can be categorized as coating and paint materials, electric and

[16]Nabi MR, Parvez MS, Wahid DF (2011) Water current and sediment flux of a tidal inlet at Salimpur coast, Chittagong, Bangladesh. The Chittagong University Journal of Science 34: 85-97.

[17]Chowdhury, SR, 1993. Study on tidal behavior along the coast of Bangladesh with special emphasis on the seasonal variation in mean sea level. MSc Thesis, Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh.

thermal insulators, oil residues, acidic liquids, fume, dust, gases and radioactive materials (Figure 2.1).

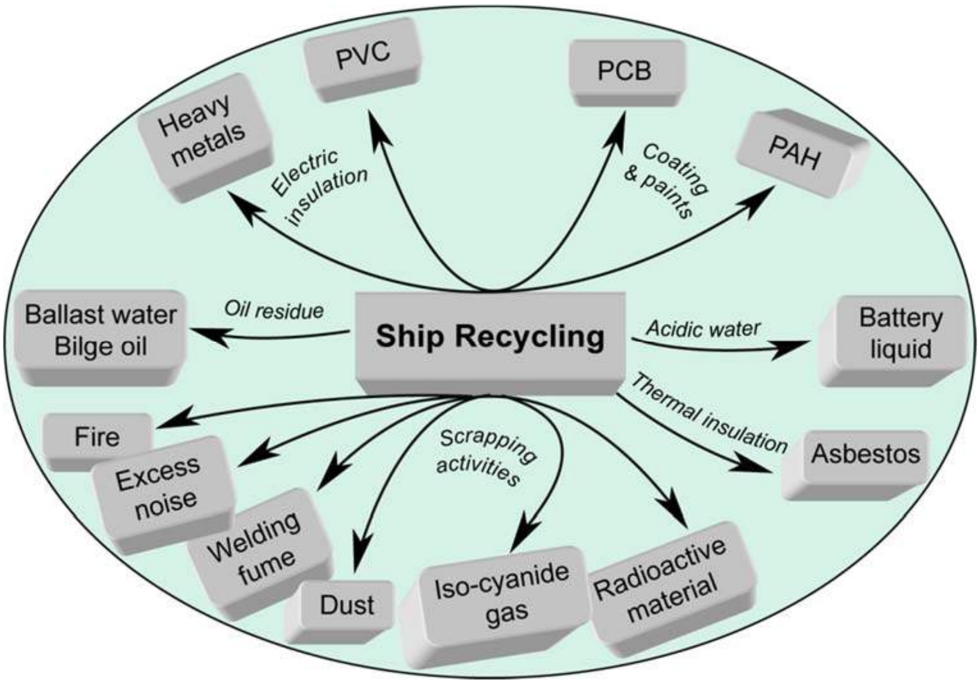


**Figure 2.1. Major pollutants from ship recycling activities (source: Local Environmental Consultants 2016[18])**

## 2.2 Changes in biota

Indicator species such as some patches of mangrove forest and salt marsh ecosystems have already been encroached through establishment of ship recycling yards at Sitakunda coast (Abdullah et al. 2013[19]) that can affect ecosystem goods and services (Figure 2.2). The geospatial extent and quantity of the area need to be systematically analyzed by using techniques such as time series high resolution satellite imagery and ground truthing.

Among the terrestrial flora, locally available herb, shrub and, to a lesser extent, trees could also have been cleared. Compared to 1989, a substantial increase of cleared (open) beach is noted due to increase of the footprint of ship recycling yards that ultimately resulted in the decline of coastal agricultural and mangrove forest areas (Abdullah et al. 2013[19]; Sharifuzzaman et al. 2016[15]). But, these studies did not substantiate the change in mangroves or other plant species. The coastal aquatic biodiversity such as phytoplankton, zooplankton, benthos, microbes and valuable fisheries are expected to be affected, but limited scientific information is available to verify such an assertion. One study has reported comparatively lower phytoplankton and zooplankton abundance and species richness, including lower occurrence of benthos in the aquatic environment of ship recycling area than that of a control site[20].

[18] Local Environmental Consultants, 2016. Evaluation of Environmental Impacts of Ship Recycling In Bangaldesh. SENSREC Phase-1, WBS Element No. TC/1514-01-2320, International Maritime Organization, 110 pp.

[19] Abdullah HM, Mahboob MG, Banu MR, Seker DZ., 2013. Monitoring the drastic growth of ship breaking yards in Sitakunda: a threat to the coastal environment of Bangladesh. Environmental Monitoring and Assessment 185(5): 3839-3851

[20]MSK Khan, SA Uddin and MA Haque. 2015. Abundance and composition of zooplankton at sitakunda coast in Chittagong, Bangladesh. Res. Agric. Livest. Fish. 2 (1): 151-160.

Some evidence[21] has also suggested that many valuable fisheries resources have disappeared from the Meghna and Karnaphuli River, possibly due to pollution from industrial sources. Kamal (2000)[22] identified 46 finfish species in the Karnaphuli river estuary. There has been a reduction from some 76 species of fish in the Karnaphuli River in 1976 to 54 in 2010, attributed to pollution, according to recent media reports of research undertaken by Chittagong University (The Daily Star 2010a[23]; Dhaka Tribune 2016[24]).

This apparent negative effect on fish diversity might also result from a number of factors including pollution caused by ship recycling, other potential sources of pollution at Sitakunda, or possibly over fishing such as excessive landing of juveniles, as has been reported by Miah et al.[26]. Such claims would need to be validated through further study.

In contrast, for example, during the field visits carried out as part of this study, stake fish nets and fry catching nets were observed in the vicinity of the ships, indicating that the fishing activities are an ongoing practice at subsistence level (Figures 2.3 and 2.4).

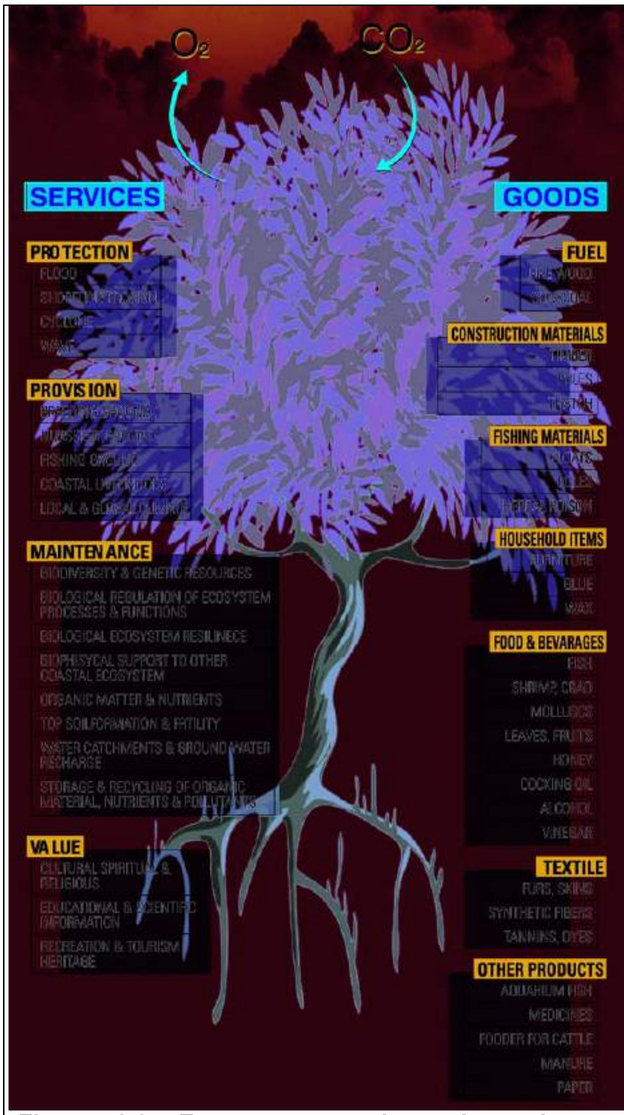


**Figure 2.2. Ecosystem goods and services of mangrove forests in the coastal zone of Bangladesh (source: Hossain 2013[25])**

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[21] Hossain, M.S., Das, N.G., Sarker, S and Rahaman, M.Z., 2012. Fish diversity and habitat relationship with environmental variables at Meghna river estuary, Bangladesh. *Egyptian Journal of Aquatic Research*, (38): 213-226.

[22] Kamal MM (2000) Temporal and spatial variation in species diversity of fishes in the Karnafully River Estuary. M.Sc. Thesis, Institute of Marine Sciences, University of Chittagong, Bangladesh.

[23] The Daily Star (2010a) Save Karnaphuli.http://www.thedailystar.net/news-detail-124560, retrieved 26/05/2016.

[24] Dhaka Tribune (2016) Native fish species decline in Karnaphuli River. http://www.dhakatribune.com/bangladesh/2016/feb/28/native-fish-species-decline-karnaphuli-riverretrieved 26/05/2016

[25] Hossain MS, 2013.Conserving Mangrove Ecosystem for Climate Change Adaptation in the Ganges Basin. Global Challenges in Integrated Coastal Zone Management, Moksness, E and Stottrup, J (ed.), 85-100.

[26] Miah MNU, Shamsuzzaman MM, Harun-Al-Rashid A, Barman PP (2015) Present Status of Coastal Fisheries in Sitakunda Coast with Special Reference on Climate Change and Fish Catch. J Aquac Res Development 6: 362. doi:10.4172/2155-9546.1000362

**Figure 2.3: Tiger shrimp (*Panaeus monodon*) catching nets in the vicinity of the ship recycling yards at Sitakunda**

**Figure 2.4: Catching near shore fisheries species by using stake nets in the vicinity of the ship recycling yards at Sitakunda**

### 2.3 General pollutant release data

As this area is a complex set-up of urban, peri-urban, agriculture, industrial and ship recycling activities, it is anticipated that pollutants ranging from heavy metals, oil, PCBs, agro-chemicals and sewage are contaminating the environment from these sources too. But they have not been studied comprehensively. The composition and quantity of pollutants from point and non-point sources (other than ship recycling), their distribution in natural systems and impacts also need to be fully studied.

### 2.4 Pollutants from ship recycling

Mostly data on metal concentrations from water and sediments are available (refer to section 4.2.4 of Part 2 for details). But the exact quantity of metals, and organic compounds such as TBTs, PVC, PCB, PAH and radioactive wastes released from each ship or each yard are not available. Recently, the World Bank (2010[27]) had investigated the presence of PCBs in soils of ship recycling yards and nothing was detected.

To improve the understanding of how the environment may be impacted from ship recycling and other anthropogenic activities as potential sources of pollution, further studies such as long-term monitoring of contaminants in fish, shrimp, crab and molluscs is necessary involving stakeholders such as DoE, academic and research institutions, BSBA and NGOs .The data should be compared with known standards of national and international institutions or agencies (e.g. Environmental Quality Standards of Bangladesh, WHO, IAEA). These can include air, water, soil, sediment and food quality (e.g. concentrations of substances in fisheries species for human consumption). Understanding of the origin, distribution and fate of key pollutants including heavy metals, oil, PCB, TBT, etc. is essential.

[27] World Bank, 2010. Ship breaking and recycling industry in Bangladesh and Pakistan. Report No. 58275-SAS, available at: http://bit.ly/R7xckJ

## 3 Field work to fill data gaps

From the foregoing a considerable amount of additional information would be required to obtain a comprehensive understanding of all the factors contributing to the environmental conditions at Sitakunda. Field studies and laboratory analyses have been conducted to the extent possible to supplement the available information concerning the conditions in marine wasters and sediments around the yards.

### 3.1 Hydrological characteristics

A total of 7 streams (locally called khal) have originated from the nearby hills and flow in an east-west direction through and to the north and south of the ship recycling zones and fall into the Bay of Bengal. The streams are tidally influenced at their discharge points but mostly become dry during the dry season, i.e. winter months (December–February). However, discharges through the streams are not gauged and have never been studied, therefore the bulk transport aspects of any pollutants (including any that may arise from industries) is also not known and their potential contribution to the water quality of the ship recycling area cannot be assessed.

Tides are semi-diurnal with two high and two low water marks during a lunar day. The Sandwip channel is a busy navigational route as well as a fishing zone utilized by small-scale fishermen and the local community. Hydrology of the area is largely governed by monsoons with occurrence of heavy showers between June and September. Coastal oceanographic processes that influence the sediment dynamics and water circulation pattern of this area are not well understood. Although, ebb and flood tidal current have been reported to influence suspended sediment flux at the Salimpur coast, Chittagong (Nabi et al. 2011[16]), microscale eddies, gyres and drifts have not been studied anywhere in Bangladesh coast. Therefore, information on the transport, mixing, dispersal and distribution of pollutants in the vicinity of the yards are unknown.

### 3.2 Pollution impacts

The mangrove forests and salt marshes have been lost in some places, specifically where the ship yards have been developed. Several of the up-stream locations have been observed, during site visits in April 2016, with abnormal water colour (e.g. yellow, black), which may be related to industrial or other discharges. Earthy materials on the intertidal mudflat and littoral zones appear dislocated due to establishment of ship recycling yards that could result in the permanent loss of critical benthic habitat and associated biotic community. According to media reports members of the local fishing community have complained about a reduction of fishing area as well as a decline in the fisheries catch and diversity although there is insufficient scientific evidence to conclude that this is an impact of ship recycling activities alone. Air and noise pollution could also be a public health problem (including yard workers). In a recent study, elevated levels of polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and hexachlorobenzene (HCB)were detected in the air near the ship breaking activities of Sitakunda area (Nøst et al. 2015[28]).

[28] Nøst TH, Halse AK, Randall S, Borgen AR, Schlabach M, Paul A, Rahman A, Breivik K, 2015. High concentrations of organic contaminants in air from ship breaking activities in Chittagong, Bangladesh. Environmental Science & Technology 49(19): 11372-11380.

## 3.3 Designated environmental zones

Nature conservation areas such as marine protected areas (MPA), ecologically critical areas (ECA), or reserved forests and sanctuaries have not been designated in the vicinity of the ship recycling zones. Moreover, no archaeological sites are evident.

## 3.4 Environmental monitoring

Some water parameters (pH, EC, TDS, Chloride, dissolved oxygen, COD, oil and grease, and $NH_3$) and ambient air (SPM, $SO_x$, $NO_x$ and sound level) quality data of only active ship recycling yards are routinely monitored by the DoE. The monitoring process is dependent on the request of a yard owner that is typically processed on payment of required fees. Thus, specific sampling period, season and frequency of sampling are not followed in this monitoring process. Similarly, precise information on tidal phase and geographic location of the sampling points are not available. Moreover, heavy metals, PCBs and biological samples are not monitored.

According to the Ship Breaking and Recycling Rules 2011, "DoE shall carry out regular monitoring of ambient air quality, soil quality, sediment quality, and marine water quality. Ministry of Industries shall carryout twice yearly monitoring of the same parameters independently through any Industrial & Scientific Research labs established or engaged by the Ship Building and Ship Recycling Board (SBSRB). In addition to this, SBSRB shall carryout the detailed analysis on improvement of the beaching methods with a mandate to evolve recycling methods targeting "zero wastes" and "zero accidents" at every year time interval."

Seawater quality parameters from 15 ship recycling yards at Sitakunda, Chittagong for the last 5 years (2012-2016) have been obtained, courtesy of DoE, and are given in Annex A. The yearly average values are shown in Table 3.1.

**Table 3.1. Yearly average seawater quality of ship recycling yards at Sitakunda, Chittagong (source: DoE)**

| **Year** | **Yearly average** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | pH | EC (µS/cm) | TDS (mg/l) | Chloride (mg/l) | DO (mg/l) | COD (mg/l) | Oil & grease (mg/l) | $NH_3$ (mg/l) |
| 2016 | 7.78 | 24830 | 12431 | 9064 | 5.7 | 366 | 5.5 | 0.19 |
| 2015 | 7.76 | 21792 | 10893 | 8608 | 5.6 | 341 | 5.7 | 0.19 |
| 2014 | 7.66 | 20597 | 10295 | 7782 | 5.4 | 318 | 5.6 | 0.20 |
| 2013 | 7.70 | 15912 | 7966 | 5755 | 5.4 | 258 | 5.2 | 0.18 |
| 2012 | 7.88 | 20715 | 10691 | 8145 | 5.3 | 341 | 6.1 | 0.27 |

*Water pH*

The pH of seawater is more on the basic side between 7.5 and 8.5, where the$HCO_3$ions predominate. Carbonate ion concentrations increase with increasing pH and when more $CO_2$ dissolves in seawater it becomes more acidic. Seawater pH of ship recycling yards in Sitakunda ranged between 7.0-8.0 with few exceptions of 8.6 and 8.8 in two recycling yards in 2016 (Figure 3.1). Very high (greater than 9.5) or very low (less than 4.5) pH values are unsuitable for most aquatic organisms. Young fish and immature stages of aquatic insects are extremely sensitive to pH levels below 5 and may die at these low pH values. High pH levels (9-14) can harm fish by denaturing cellular membranes.

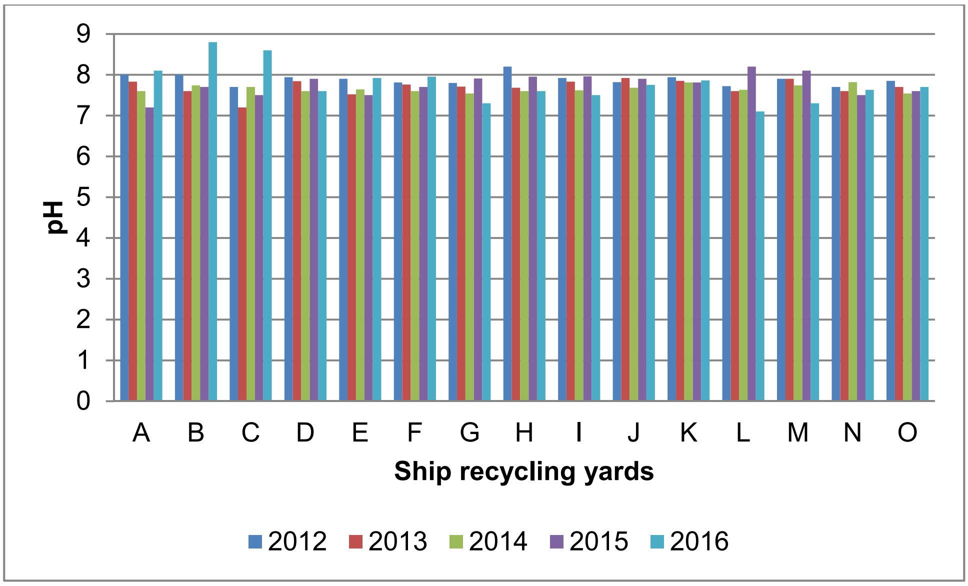


**Figure 3.1. Seawater pH of ship recycling yards at Sitakunda, Chittagong (from DoE)**

*Electrical conductivity (EC)*

EC is the ability of water to conduct an electrical current, and the dissolved ions are the conductors. Saline water usually consists of four major cations, $Ca^{+2}$, $Mg^{+2}$, $Na^{+}$ and $K^{+}$, and four major anions, $HCO_3^{-}$, $CO_3^{-2}$, $SO_4^{-2}$ and $Cl^{-}$.Nitrates ($NO_3^{-2}$) and phosphates ($PO_4^{-3}$) are minor contributors to conductivity, although they are important biologically (CWT 2004[29]). EC is expressed in micro Siemens per centimetre (μS/cm).Rainwater conductivity equals zero, while typical drinking water has less than 100 μS/cm and seawater possesses a conductivity of about 50,000 μS/cm (Assiry et al. 2010[30]).Agricultural runoff or a sewage waste can increase conductivity due to the additional chloride, phosphate and nitrate ions (Wetzel 2001[31]). An oil spill or addition of other organic compounds would decrease conductivity as these elements do not break down into ions (Murphy 2007[32]). As tides rise, saltwater is pushed toward the coast and raises conductivity. Conversely when tides fall, saltwater is pulled back toward the ocean and lowers conductivity. Moreover, conductivity increases in summer due to lower water flow and evaporation. On the other side of the scale, precipitation can increase water volume and level, lowering conductivity (Pattillo 1994[33]). Average EC varies between 15,911 and 24,830 μS/cm in the waters of Sitakunda coastal area (Figure 3.2).

[29]CWT (Clean Water Team), 2004.Electrical conductivity/salinity Fact Sheet, FS-3.1.3.0 (EC). In: The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment, Version 2.0. Division of Water Quality, California State Water Resources Control Board (SWRCB), Sacramento, CA.

[30]Assiry AM, Gaily MH, Alsamee M, Sarifudin A, 2010. Electrical conductivity of seawater during ohmic heating. Desalination 260 (1-3): 9-17.

[31] Wetzel RG, 2001. Limnology: Lake and River Ecosystems (3rd ed.). San Diego, CA: Academic Press.

[32] Murphy S, 2007. General Information on Solids. In City of Boulder: USGS Water Quality Monitoring. Retrieved from http://bcn.boulder.co.us/basin/data/NEW/info/TSS.html

[33]Pattillo C, 1994. Determining the Settling Velocity. In Introduction to Biochemical Engineering Term Project. http://www.rpi.edu/dept/chem-eng/Biotech-Environ/SEDIMENT/sedsettle.html

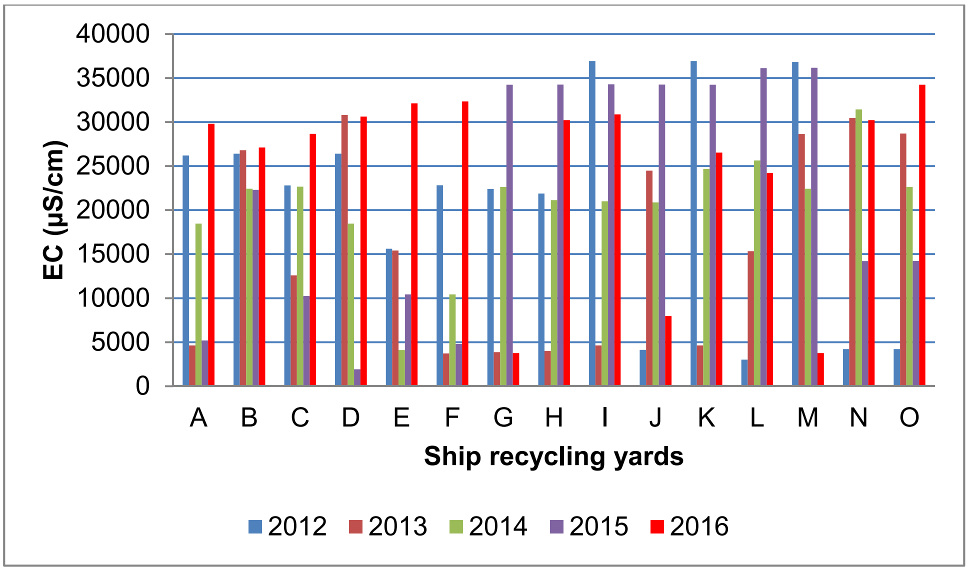


**Figure 3.2. The electrical conductivity of seawater of ship recycling yards at Sitakunda, Chittagong (from DoE)**

*Total dissolved solids (TDS)*

TDS are the total amount of mobile charged ions (hence salinity affects the values), including minerals, salts or metals dissolved in a given volume of water, expressed as mg per unit volume of water (mg/L). TDS in surface waters come from the solvent action of water in contact with minerals in the earth, agricultural and residential runoff, leaching of soil contamination and used water from industrial or sewage treatment plants[34]. Depending on the ionic properties, excessive TDS can produce toxic effects on fish and fish eggs. Total dissolved solids of 2200-3600 mg/L reduced hatching and survival rates in salmonids, perch and pike[35,36]. A level of 400 ppm or less is recommended for freshwater fish, saltwater fish require 5000 to 50,000 ppm (Table 3.2). TDS are also important for proper osmotic regulation, (the relationship of water versus dissolved solids in the cells and the external environment[37]). In the Sitakunda coastal water, a 5 year average (2012-2016) of TDS was between 7,966 and 12,430 mg/L (Figure 3. 3).

**Table 3.2 Reported total dissolved solids in different water bodies (after Heath 1983[38])**

| Types of water | TDS (mg/L) |
|---|---|
| Drinking water standard | 1000 (WHO and EC) |
| Irrigation water standard | <2,000 |
| Recommended for freshwater fish | 400 ppm |
| Recommended for saltwater fish | 5000-50,000 ppm |
| Fresh water | 0-1,000 |
| Slightly saline | 1,000-3,000 |
| Moderately saline | 3,000-10,000 |
| Very saline | 10,000-35,000 |
| Brine | >35,000 |

[34] http://www.iccontrols.com/files/TDS_Measurement.pdf
[35] http://www.michigan.gov/documents/deq/wb-npdes-TotalSuspendedSolids_247238_7.pdf
[36] Weber-Scannell PK, Duffy LK, 2007. Effects of Total Dissolved Solids on Aquatic Organisms: A Review of Literature and Recommendation for Salmonid Species. American Journal of Environmental Sciences 3 (1): 1-6.
[37] http://www.tdsmeter.co.uk/abouttds_aquaculture.html
[38] Heath RC, 1983. Basic ground water hydrology, USGS Water Supply Paper 2220, 84 p.

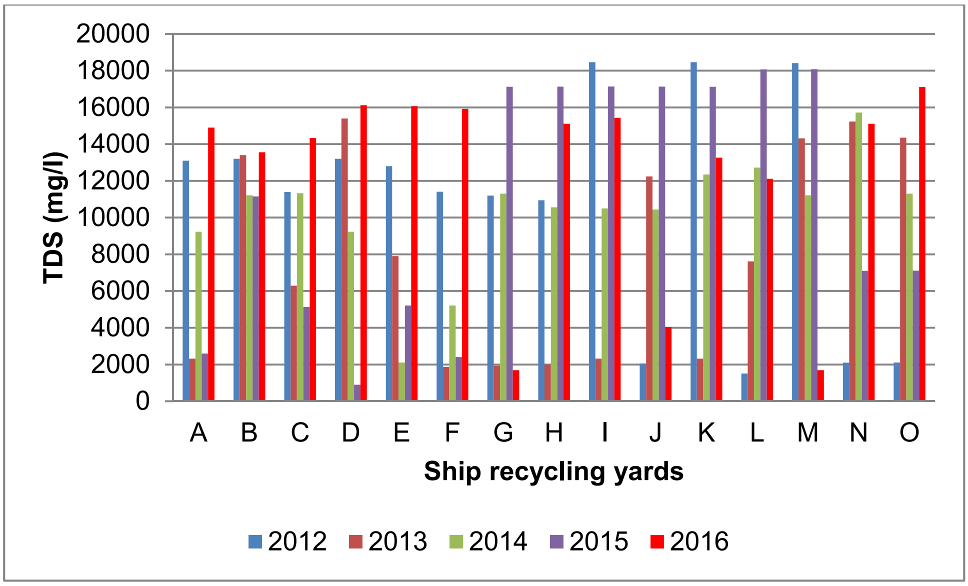


**Figure 3.3. Total Dissolved Solids in seawater of ship recycling yards at Sitakunda, Chittagong (from DoE)**

*Chloride ($Cl^-$)*

Chloride, in the form of $Cl^-$ ion, is one of the major inorganic anions, or negative ions, in saltwater and freshwater. Chloride in surface (fresh) waters can be toxic to many forms of aquatic life such as fish, macro-invertebrates, insects, and amphibians. Elevated chloride levels can threaten the health of food sources and pose a risk to species survival, growth, and/or reproduction (Siegel 2007[39])(this relates to contamination of surface (fresh) waters from road salt such as is used for de-icing; the salinity of sea water is not toxic to marine organisms). The presence of salt also releases toxic metals from sediment and when released into the water can inhibit nutrients and dissolved oxygen within the water that aquatic species rely on. Seawater has a natural chloride ion concentration of about 19,400 mg/L (a salinity of 3.5‰) and brackish water in tidal estuaries may have chloride levels between 500 and 5,000 mg/L (salinity of 1-10‰)[40]. Yearly average chloride contents were found between 5755 and 9064 mg/L in the water of Sitakunda coastal area (Figure 3.4).Table 3.3summarizes various water quality standards and guidelines with respect to human health, wildlife, aquatic species, and vegetation. Note that the human health standards are based on drinking water at the tap while the other standards and guidelines are for surface (fresh) waters.

[39] Siegel L, 2007. Hazard identification for human and ecological effects of sodium chloride road salt. State of New Hampshire, Department of Environmental Services, 19 pp.

[40]http://www2.vernier.com/sample_labs/WQV-15-COMP-chloride_salinity.pdf

**Table 3.3 Surface Water quality standards - chloride (see Siegel 2007[39])**

| | Water quality standards ($Cl^-$ mg/L) | Remarks |
|---|---|---|
| Human health | 250 | EPA drinking water quality standards |
| Wildlife | 600 | Nagpal et al. 2003[41] |
| Aquatic organisms (fresh water) | 860 (1 hour average)<br>230 (4 days average) | DES water quality standard |
| Terrestrial plants | 300 | Groundwater source |
| Aquatic plants | 200-36,400 | USEPA 1988[42] |

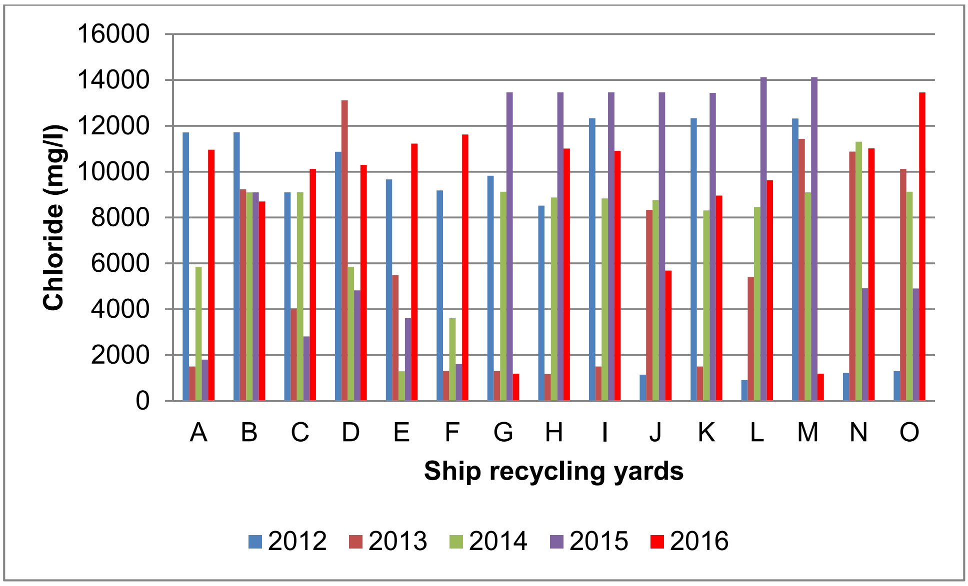


**Figure 3.4 Chloride in seawater at ship recycling yards, Sitakunda, Chittagong (from DoE)**

*Chemical Oxygen Demand (COD)*

COD is a measure of oxygen equivalent of the organic matter content of water that is susceptible to oxidation by a strong chemical oxidant. Thus, COD is a reliable parameter for judging pollution the potential of waste waters (e.g. tanneries) and the extent of pollution in water bodies (Amirkolaie 2008[43]). COD increases with increasing concentration of organic matter (Boyd 1981[44]). In the Sitakunda coastal water average (2012-2016) COD ranged from 258 to 366 mg/L (Figure 3.5). High levels may arise due to disposal of untreated wastes from nearby industries into the coastal water. Therefore, high value of COD is indicative of high organic pollution (Upkar and Vyas 1992[45]). By comparison tannery effluents can have COD of 12,840 (Jahan et al 2014[46]), whereas water with more than 8 mg/L of COD is unsuitable for swimming in Japan (Tomimura 2009[47]).

[41]Nagpal NK, Levy DA, MacDonald DD, 2003. Ambient Water Quality Guidelines for Chloride: Overview Report. Original Signed by Margaret Eckenfelder Assistant Deputy Minister Water, Land and Sir Protection. Government of British Columbia.
[42]USEPA. 1988. Ambient Aquatic Life Water Quality Criteria for Chloride. EPA 440/5-88-001.
[43]Amirkolaie AK, 2008. Environmental Impact of Nutrient Discharged by Aquaculture Waste Water on the Haraz River. *Journal of Fisheries and Aquatic Science, 3: 275-279.*
[44]Boyd CE, 1981. Water quality in warm water fish ponds. Craftmaster Printers. Inc. Albana.
[45]Upkar NA, Vyas A, 1992. Correlation between copepods and limnochemistry of Mansarovar reservoir, Bhopal. J. Environ. Biol.13, 281-290.
[46]Jahan, M. A. Aet al. Characterization of tannery wastewater and its treatment by aquatic macrophytes and algae Bangladesh J. Sci. Ind. Res. 49(4), 233-242, 2014(Available online at www.banglajol.info)

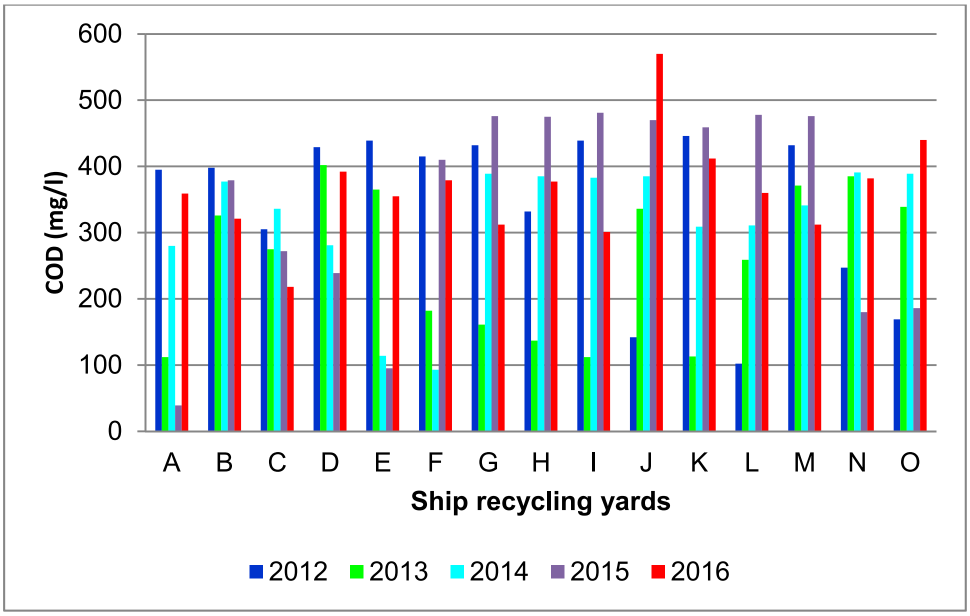


**Figure 3.5 Chemical Oxygen Demand in seawater at ship recycling yards, Sitakunda, Chittagong (from DoE)**

*Dissolved oxygen (DO)*

Levels of dissolved oxygen vary depending on factors including water temperature, time of day, season, depth, and rate of water flow. Typically dissolved oxygen reaches its peak during the day, but decreases at night when photosynthesis stops and oxygen consuming processes such as respiration continues. Between 2015 and 2016, DO level of ship recycling yards at Sitakunda ranged from5.0-6.5 mg/l with record of little elevated levels, i.e. 6.9, 6.6 and 6.5 mg/l in three recycling yards (Figure 3.6). The existing level of dissolved oxygen is favourable to aquatic organisms including fisheries.

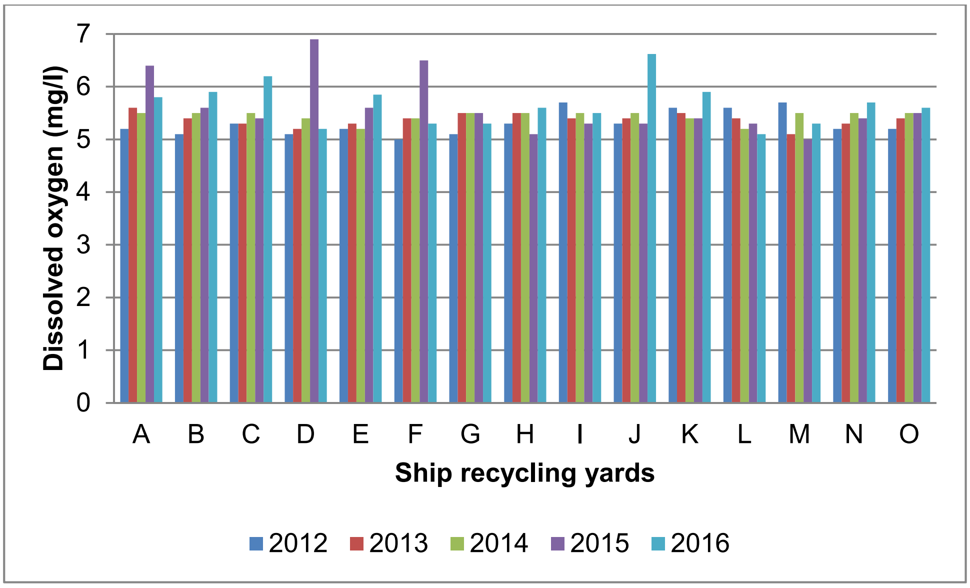


**Figure 3.6. Dissolved oxygen contents in seawater of ship recycling yards at Sitakunda, Chittagong (from DoE)**

[47]Tomimura C, 2009. Report of Seawater Monitoring.https://www.scribd.com/doc/23183510/Seawater-Quality-Monitoring-Report

*Oil and grease (OG)*

The concentration of oil and grease, which is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil and cooking oil, is typically measured within a body of water including lake, river, sea, and wastewater. It is an important parameter for water quality and safety. Organisms in the intertidal zone are highly sensitive to damage by drifting oil. Oil and grease need to be contained and/or recycled to keep them from entering the environment. OG in water can cause surface films that result in lethal effects on fish, asphyxiation of benthic life forms, and its shoreline/beach deposits can have adverse aesthetic effects. It can induce human health risks when discharged especially in ground waters. Additionally, OG may interfere with aerobic and anaerobic biological processes and lead to decreased wastewater treatment efficiency.

The toxicity of the water-soluble fraction of oils to selected marine organisms is shown in table 3.4. The data indicated the fish species shown are susceptible at Water Soluble Fraction (WSF) concentrations of >20 mg/L and some invertebrate larval stages at 3-26mg/L. Table 3.5 shows examples of water quality criteria, guidelines and standards for oil and grease from various locations. The OG concentrations of ship recycling yards at Sitakunda ranged between 4.0-7.0 mg/l with record of little higher levels, i.e.7.8 and 7.2 mg/l for two recycling yards (Figure 3.7),indicating generally light to medium contamination in comparison with the toxicity data of Table 3.4.

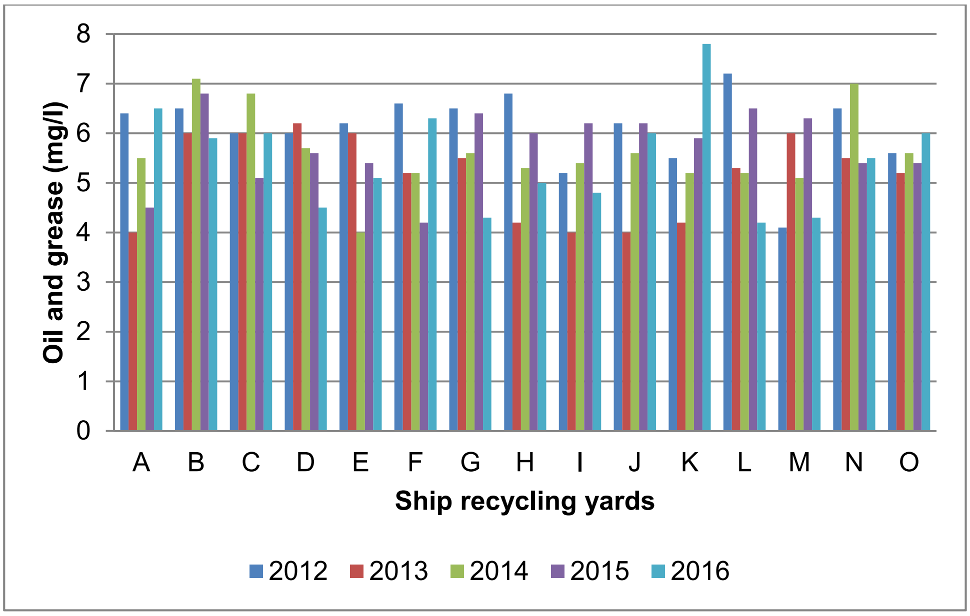


**Figure 3.7 Oil and grease concentrations in seawater of ship recycling yards at Sitakunda, Chittagong (from DoE)**

**Table 3.4 Acute and chronic toxicity of the water-soluble fraction of oils to marine organisms (source: Tong et al. 1999[48])**

| Test Organism | Life Stage | Test Duration | Effect Measured | Temp. (°C) | Salinity (ppt) | Test System[1] | DQ[2] | Conc. (mg/L WSF) |
|---|---|---|---|---|---|---|---|---|
| **FISH** | | | | | | | | |
| Seabass *Lates calcarifer* | juvenile | 96 h | LC50 | tropical ambient | seawater | S, M | 2 | 23.1 |
| Mullet *Mugil* sp. | juvenile | 96 h | LC50 | tropical ambient | seawater | S, M | 2 | 22.8 |
| **INVERTEBRATES** | | | | | | | | |
| Malaysian giant prawn *Macrobrachium rosenbergii* | newly hatched larvae (stage 6-8) | 48 h | LC50 | 27-28 | 12 | S, M | 1 | 3.6 |
| Malaysian giant prawn *Macrobrachium rosenbergii* | eggs | 12 d | EC50 (hatching) | 26 - 27 | 12 | FT, M | 1 | 16.6 |
| Tiger prawn *Penaeus monodon* | PL30 | 96 h | LC50 | 28 | 28 | S, M | 1 | 13.8 |
| Tiger prawn *Penaeus monodon* | PL30 | 6 weeks | significantly reduced growth | 28 | 28 | FT, M | 2 | >3.0 |
| Tiger prawn *Penaeus monodon* | larvae | 96 h | LC50 | tropical ambient | seawater | S, M | 2 | 20.3 |
| Crab *Scylla serrata* | - | 96 h | LC50 | tropical ambient | seawater | S, M | 2 | >23.6 |
| Cockle *Anadara granosa* | - | 96 h | LC50 | tropical ambient | seawater | S, M | 2 | 26.2 |

**Table 3.5 Water quality guidelines and standards for oil and grease (source: Tong et al. 1999[48])**

| Location | Aquatic environment | Level (mg/l) | Remarks |
|---|---|---|---|
| California | Oceanic | Narrative | Floating particulates and grease shall not be visible |
| Florida | All marine water | Narrative | Dissolved or emulsified oils and greases shall not exceed 5.0 mg/l. No undissolved oil, or visible oil defined as iridescence, shall be present so as to cause taste or odour, or otherwise interfere with the beneficial use of waters |
| U.S. EPA | All marine water | Narrative | 0.01 of the lowest continuous flow 96-h $LC_{50}$ to several important freshwater and marine species, each having a demonstrated susceptibility to oils and petrochemicals. Levels of oils or petrochemicals in the sediment that cause deleterious effects to the biota should not be allowed. Surface waters shall be virtually free from floating nonpetroleum oils of vegetable or animal origin as well as petroleum-derived oils |
| Thailand | Open coastal | Not visible | Conservation of natural areas, |

[48]Tong SL, Goh SH, Abdula AR, Tahir NM, Wang CW, 1999. AMWQC for Oil and Grease.http://www.anp.gov.br/brnd/round9/round9/guias_R9/perfuracao_R9/Bibliografia/oil_grease%20criteria.pdf (accessed on 03/10/2016)

| | | | |
|---|---|---|---|
| | | | aquaculture and shellfish |
| Vietnam | Coastal water | 1.0 mg/l | Oil and fat suspension: aquatic cultivation areas |
| Philippines | All marine water | 1.0-3.0 mg/l | 1.0mg/l: propagation, survival and harvesting of shellfish; tourist zones and national marine parks and reserves; coral reef parks and reserves<br>2.0 mg/l: areas regularly used by the public for bathing, swimming, skin diving, etc.; spawning areas for milkfish or "bangus" and similar species<br>3.0 mg/l: boating; commercial and sustenance fishing |
| Indonesia | Marine water | 5.0 mg/l | Oil content: for marine life mariculture and conservation |

*Ammonia ($NH_3$)*

High levels of aqueous ammonia may cause fish to suffer a loss of equilibrium, hyperexcitability, increased respiratory activity and oxygen uptake, and increased heart rate. Chronic ammonia poisoning slows growth and lowers disease resistance in fish (Noga 2010[49]). According to Boardman et al. (2004)[50], the chronic criterion for ammonia in three marine fish and three marine invertebrates ranged from 0.035 to 0.081 mg/l un-ionized ammonia. Moreover, the species mean acute values (SMAVs = i.e. the geometric means of the 48-and 96-h LC50s) of red drum (*Sciaenopsocellatus*), sargassum shrimp (*Latreutesfucorum*), and prawn (*Macrobrachiumrosenbergii*) ranged from 0.492 to 0.777 mg/l (US EPA 1989[51]). In particular, mullet (*Mugilplatanus*) is less sensitive to ammonia in saltwater that in freshwater and marine shrimp (*Penaeus* spp.) are more tolerant to ammonia at higher salinity levels (Boardman et al. (2004)[50]).

Ammonia concentrations in the waters of ship recycling yards at Sitakunda were generally 0.2 mg/l with one record of a higher value of 1.2 mg/l in 2012 (Figure 3.8).

[49]Noga EJ, 2010. Fish Disease: Diagnosis and Treatment, 2nd edn. Iowa State University Press, Ames, Iowa.
[50]Boardman GD, Starbuck SM, Hudgins DB, Li X, Kuhn DD, 2004. Toxicity of ammonia to three marine fish and three marine invertebrates. Environmental Toxicology 19: 134-142.
[51]US EPA (US Environmental Protection Agency), 1989.Ambient Water Quality Criteria for Ammonia (Saltwater)-1989.EPA 440/5-88-004 Office of Water Regulations and Standards, Criteria and Standards, Washington, DC, USA.

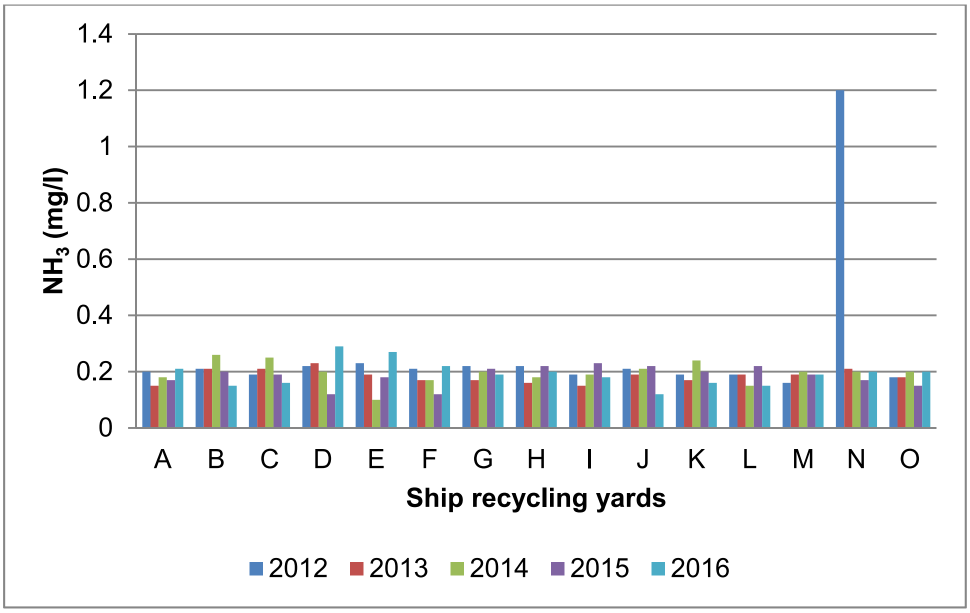


**Figure 3.8. Ammonia concentrations in seawater of ship recycling yards at Sitakunda, Chittagong (from DoE)**

*Air and sound quality*

Upon the payment of required fees by the ship scrapping yard owner, DoE monitor the air and sound quality parameters irrespective of specific sampling period, season and frequency as well as precise information on geographic location of the sampling points. Air quality and sound quality parameters of 15 ship recycling yards at Sitakunda, Chittagong are given in Annex B and the yearly average is shown in Table 3.6.

**Table 3.6. Yearly average air quality and sound quality at ship recycling yards, Sitakunda (source: DoE)**

| Year | Yearly average | | | |
|---|---|---|---|---|
| | SPM (μg/m$^3$) | SOx (μg/m$^3$) | NOx (μg/m$^3$) | Sound level (dBa) |
| 2016 | 163 | 5.4 | 9 | 72 |
| 2015 | 158 | 4.1 | 7.3 | 68 |
| 2014 | 151 | 7.6 | 14.4 | 64 |
| 2013 | 141 | 6.0 | 13.1 | 62 |
| 2012 | 138 | 6.2 | 12.7 | 62 |
| Standard limit | <200 | <80 | <100 | <75 |

*Suspended particulate matter (SPM)*

Suspended particulate matter is the sum of all solid and liquid particles suspended in air. This complex mixture includes both organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets[52]. These particles may vary greatly in size, composition, and origin.

[52]Fine particles of less than 3 microns in diameter enter the nose and throat, reach the lungs, and cause breathing problems and irritation of the lung capillaries. Particulate matter is associated with respiratory morbidity, deficiencies in pulmonary (lung) functions including decreased lung function (especially in children), and lung cancer with the consequence of increased mortality. Particulate matter has also the potential to modify the climate through the formation of clouds and snow. Particles also contribute to acid deposition and may absorb solar radiation and impair/reduce visibility.

SPM concentrations in ambient air of ship recycling yards were between 100 and 180 μg/m$^3$ during 2012-2016, and these results are well below the standard limit set in Bangladesh (<200 μg/m$^3$; BNAAQS 2005[53]) (Figure 3.9).

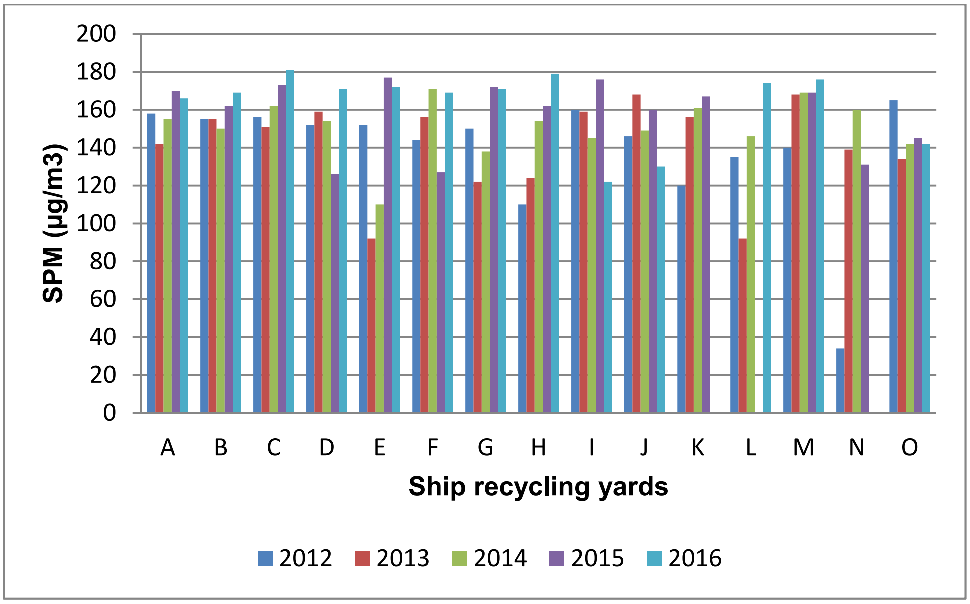


**Figure 3.9. Level of suspended particulate matter in ambient air of ship recycling yards at Sitakunda, Chittagong (from DoE)**

*Sound levels*[54]

During a single day, people living in a typical urban environment can experience a wide range of sounds in many locations, including shopping malls, schools, the workplace, recreational centres, and the home. In its 1999*Guidelines for Community Noise*, the World Health Organization (WHO[55]) declared, “Worldwide, noise-induced hearing impairment is the most prevalent irreversible occupational hazard, and it is estimated that 120 million people worldwide have disabling hearing difficulties.”

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[53]BNAAQS (Bangladesh National Ambient Air Quality Standards), 2005.http://case.doe.gov.bd/file_zone/feedback/Revision%20of%20National%20Ambient%20Air%20Quality%20Standard.pdf(accessed on 03/10/2016)

[54]Prolonged exposure to certain levels of sound can actually change the structure of the hair cells in the inner ear, resulting in hearing loss. It can also cause tinnitus, a ringing, roaring, buzzing, or clicking in the ears. Noise levels above 80 dBa are associated with both an increase in aggressive behaviour and a decrease in behaviour helpful to others.

Non-auditory effects of noise exposure are those effects that don’t cause hearing loss but still can be measured, such as elevated blood pressure, loss of sleep, increased heart rate, cardiovascular constriction, laboured breathing, and changes in brain chemistry. According to the WHO *Guidelines for Community Noise*, “these health effects, in turn, can lead to social handicap, reduced productivity, decreased performance in learning, absenteeism in the workplace and school, increased drug use, and accidents.” Wildlife faces more problems with noise pollution since they are more dependent on sound. Species that depend on mating calls to reproduce are often unable to hear these calls due to excessive man made noise. As a result, they are unable to reproduce and cause declining populations. Others require sound waves to echo-locate and find their way when migrating. Disturbing their sound signals means they get lost easily and do not migrate when they should.

[55] WHO, 1999. Guidelines for Community Noise. Edited by Berglund B, Lindvall T, Schwela DH, Goh KT. World Health Organization, Geneva. http://www.who.int/docstore/peh/noise/guidelines2.html (accessed 6 October 2016)

Sound levels in the ship recycling yards were between 60 and 75 Decibel (dBa) during 2012-2016, indicating that these data are close to the standard limit for Bangladesh (below 75 dBa) (Figure 3.10).

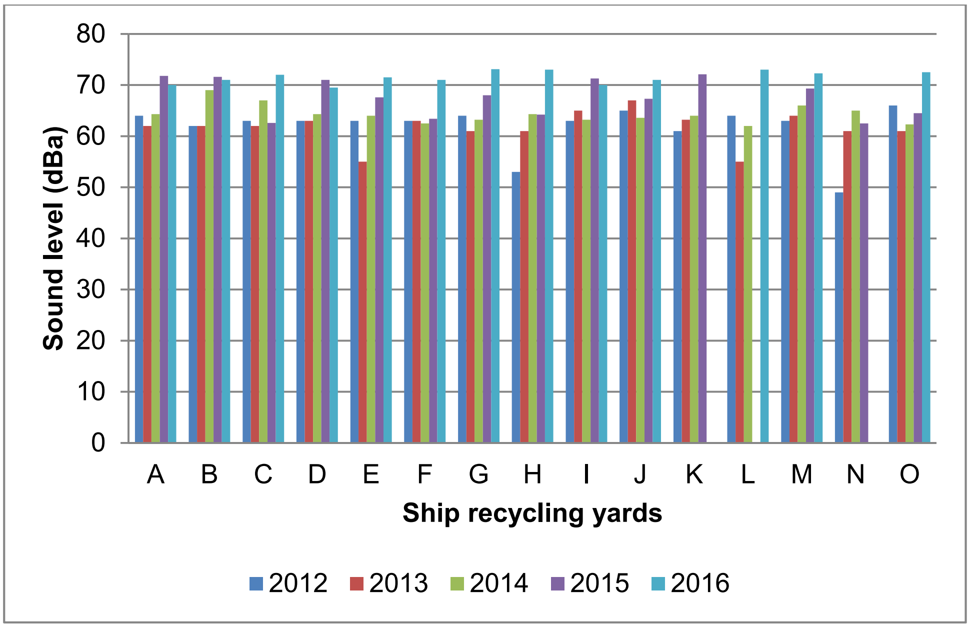


**Figure 3.10.Sound levels in the ship recycling yards at Sitakunda, Chittagong (from DoE)**

### 3.5 Fieldwork- sample collection and analysis

Ship recycling activities in the coastal environment of Sitakunda, Chittagong have the potential to introduce significant amount of pollutants into nearby aquatic ecosystems. The tidal currents change direction in about 6 hours following a semidiurnal pattern, (Figure 3.11). This not only influences transport and dispersion of pollutants but also affects the sedimentation processes significantly. Thus, monitoring systems are essential to track long-existing pollution processes. The lack of an established monitoring system makes it difficult to draw certain conclusion about the long-term results of ship recycling activities. The present initiative has been undertaken to detect the concentration of metals from the sub-surface water and superficial sediment of the Karnaphuli River, Sitakunda coast and Sandwip near shore environment to assist in establishing a baseline and indicate potential for harm to the environment.

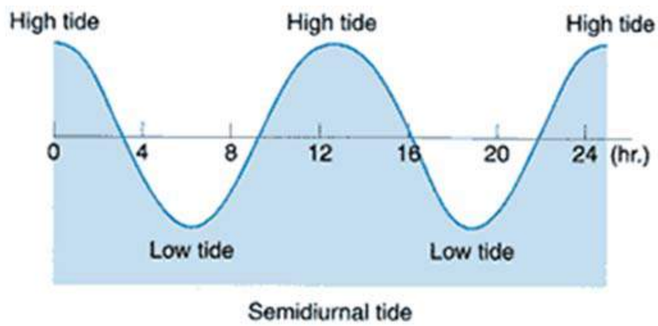


**Figure 3.11 Showing semidiurnal tidal pattern during a 24 hour period**

Water and sediment samples were collected from 4 locations with 3 replicates each. Two locations were within the ship recycling zone and one location in the Karnaphuli River of Chittagong port area. The fourth location (as a control location) was in the southeast side of the Sandwip Island (Figure 3.12). The locations of sediment and water sample with total number of samples are showed in Table 3.7.

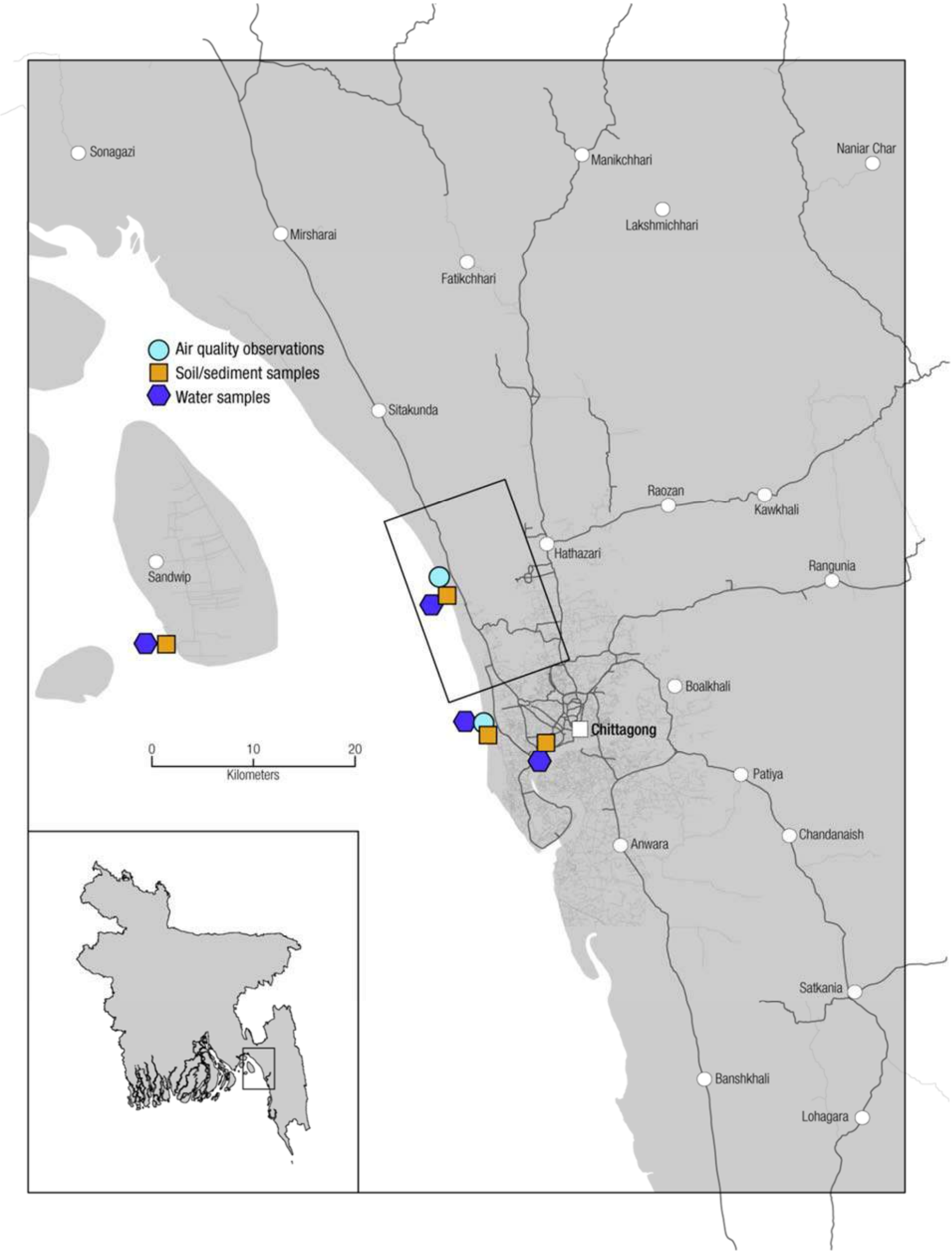


**Figure 3.12 Location of air, water and sediment sample collection/observation points in the coastal environment of Chittagong, Bangladesh**

**Table 3.7.Sediment and water sample locations and total samples with replicates**

| Location | Type of sample | |
|---|---|---|
| | Sediment (3 replicates) | Water (3 replicates) |
| Ship yard – 1 | 3 | 3 |
| Ship yard – 2 | 3 | 3 |
| Chittagong port area (Karnaphuli River) | 3 | 3 |
| Sandwip Island (control) | 3 | 3 |
| **Total samples** | **12** | **12** |
| **Total data sets** | **24** | |

Pollutants in the coastal waters are the product of a balance between inputs of high concentrations from rivers and flushing with oceanic water containing low concentrations. The results of water and sediment quality parameters and concentrations of metals and oil-grease of the investigated area showed indiscriminate rise and fall (Table 3.8 and Table 3.9). However, climate and hydrologic extremes (such as floods, storm surges, and tropical cyclones) can affect the anthropogenic inputs, residence time and concentration of metals and oil-grease in the water column. Sediments accumulate metals and oil-grease, and affect the near bottom water layer due to resuspension or dissolution process. Polluted sediments may act as a secondary pollution source for the marine environment.

**Table 3.8 Water quality parameters with corresponding concentration of metals and oil-grease in the Chittagong port area (i.e. Karnaphuli River), ship recycling yards (i.e. Sitakunda coastal area) and control location (i.e. Sandwip Island)**

| Parameter | Unit | Karnaphuli River | South of ship yard | Ship recycling yard | Sandwip Island |
|---|---|---|---|---|---|
| Salinity | ppt | 0.00 | 2.00 | 1.00 | 0.00 |
| Temperature | °C | 29.00 | 32.00 | 31.00 | 29.00 |
| pH | | 7.13 | 6.93 | 7.53 | 8.13 |
| DO | mg/l | 8.57 | 8.57 | 10.00 | 8.58 |
| BOD | mg/l | 4.11 | 5.92 | 5.72 | 3.67 |
| TDS | mg/l | 0.17 | 2.57 | 2.20 | 1.13 |
| $NH_4$-$N_2$ | µg/l | 24.34 | 27.36 | 27.48 | 48.33 |
| $NO_2$ | µg/l | 1.53 | 0.66 | 1.65 | 0.60 |
| $PO_4$ | µg/l | 1.08 | 1.75 | 19.30 | 1.35 |
| Cu | ppm | 0.00 | 0.00 | 0.00 | 0.00 |
| Fe | ppm | 0.16 | 0.02 | 0.08 | 0.08 |
| Mn | ppm | 0.00 | 0.00 | 0.00 | 0.00 |
| Zn | ppm | 0.02 | 0.03 | 0.03 | 0.02 |
| Pb | ppm | 0.16 | 0.01 | 0.01 | 0.03 |
| Cd | ppm | 0.0000 | 0.0032 | 0.0007 | 0.0008 |
| Hg | mg/l | <0.001 | <0.001 | <0.001 | <0.001 |
| Cr | ppm | 0.0005 | 0.0020 | 0.0057 | 0.009 |
| Ni | ppm | 0.0053 | 0.0150 | 0.0227 | 0.024 |
| Oil & Grease | mg/l | 9.00 | 60.00 | 81.00 | 61.00 |
| PAH'S | | - | - | - | - |
| PCB | | - | - | - | - |

The level of salinity tends to zero during the rainy season (July-September) in the coastal waters of Bangladesh and thus, a reduced level of salinity (0-2 ppt) was observed in the Karnaphuli estuary, Sitakunda coastal area and Sandwip Island. Maximum BOD value in the studied area was5.92 mg/l with lower level (3.67 mg/l) recorded from control site, i.e. Sandwip Island. These BOD levels are within the recommended range (3-5mg/l, USEPA) that is conducive for protection and propagation of aquatic species, and sustaining natural system. Because of semidiurnal tides, strong currents and distinct seasonal influence, the magnitude of organic discharge from point- and non-point sources into the studied sites and the corresponding BOD level may not always reflect discharges accurately and can vary on temporal and spatial scales. Distributions of metals in sediment (see below) were not related to the corresponding distributions in water, although concentrations of metals in water were low, the corresponding amounts in sediments were high. The coastal environment of Chittagong has most likely been polluted from a mix of ship recycling wastes, industrial effluents, agricultural residues, land washout, port operation and domestic sewage. Being a dynamic system (due to the reasons mentioned above) much of the fine grained materials are unable to settle down or deposit, thereby preventing any detectable build-up of pollutants (Table 3.8) in the immediate environment. The variation of oil and grease concentration ranged from 9-81 mg/l. Accidental spillage of oil and oily substances in the domestic shipping route (close to Sandwip Island) may occur from ships, oil tankers and other carrying vessels, which indicate higher concentration (61 mg/l) of oil and grease near the Sandwip Island.

**Table 3.9. Sediment quality parameters with corresponding concentration of metals and oil-grease in the Chittagong port area (i.e. Karnaphuli River), ship recycling yards (i.e. Sitakunda coastal area) and control location (i.e. Sandwip Island)**

| Parameters | Unit | Karnaphuli River | South of ship yard | Ship recycling yard | Sandwip |
|---|---|---|---|---|---|
| Salinity | ppt | 0.00 | 0.00 | 0.00 | 0.00 |
| pH | | 6.67 | 6.60 | 6.50 | 6.17 |
| $NH_4$-$N_2$ | µg/l | 57.56 | 59.90 | 86.69 | 70.82 |
| $NO_2$ | µg/l | 2.74 | 1.57 | 8.02 | 3.29 |
| $PO_4$ | µg/l | 0.95 | 1.43 | 6.84 | 1.13 |
| Cu | ppm | 3.78 | 5.29 | 5.33 | 5.74 |
| Fe | ppm | 107.62 | 46.42 | 46.13 | 88.63 |
| Mn | ppm | 26.48 | 21.77 | 22.81 | 19.44 |
| Zn | ppm | 1.85 | 1.12 | 1.75 | 0.97 |
| Pb | ppm | 15.96 | 16.17 | 18.72 | 17.57 |
| Cd | ppm | 0.66 | 0.00 | 0.00 | 0.00 |
| Hg | mg/kg | 0.07 | 0.05 | 1.60 | 0.05 |
| Cr | ppm | 61.75 | 49.27 | 49.76 | 45.74 |
| Ni | ppm | 49.70 | 44.59 | 49.36 | 46.67 |
| Oil & Grease | mg/kg | <5.0 | <5.0 | <5.0 | <5.0 |
| PAH'S | | - | - | - | - |
| PCB | | - | - | - | - |

The results of oil-grease in sediments of the coastal environment of Chittagong indicate a reduced level of contamination (<5.0 mg/kg) than those recorded for water column (9-81 mg/l). Lower concentrations in sediment indicate the handling of light molecular weight oils. These oil residues are volatile and float on the water surface and ultimately washout to the Bay of Bengal by semi-diurnal tidal characteristics (Hossain et al. 2006[56]). Thus, these types of oil residues have little scope to contaminate the sediment. In general, accumulation of metal and oil-grease are expected to occur in low concentrations in water but high concentrations in sediments. This does not hold for the present study due to fact that the dynamics of water movement may be restricting accumulation on the seafloor or intertidal mudflat. Concentrations of Hg, Cd, Pb, Cr, Cu, Zn, Mn and Ni around Aliaga (Turkey) ship recycling facilities were higher in comparison to respective background levels. The metal levels (µg/g) ranged from 0.32-7.02 for Hg, 0.06-3.94 for Cd, 26-751 for Pb, 65-264 for Cr, 20-703 for Cu, 86-970 for Zn, 283-1,192 for Mn, 28-240 for Ni, 32,390-54,666 for Fe and 4,006-41,962 for Al (Neser et al. 2012[57]). Moreover, severe metal accumulation was observed at an abandoned shipyard site in Hong Kong, where the concentrations of Cu (653 ppm), Pb (1485 ppm) and Zn (1622 ppm) exceeded environmental standards (Chiu et al. 2006[58]). Previous study results on the levels of metal contaminations in sediments in the vicinity of the ship recycling area are given in Table 3.10. Also, standard guidelines of safety limits for metal concentrations in marine sediment as set by US EPA are summarized in Table 3.11.

[56]Hossain MS, Islam MS, Chowdhury MAT, 2006. Shore Based Pollution Sources of the Karnafully River and the Effects of Oil-Grease on the Riverine Environment. *The Journal of Geo-Environment*, Vol. 5: 55-66.

[57]Neser G, Kontas A, Unsalan D, Uluturhan E, Altay O, Darılmaz E, Ku¨c¸u¨ksezgin F, Tekogul N, Yercan F., 2012. Heavy metals contamination levels at the Coast of Aliaga (Turkey) ship recycling zone. Mar Pollut Bull 64:882-887.

[58] Chiu SW, Ho KM, Chan SS, So OM, Lai KH., 2006. Characterization of contamination in and toxicities of a shipyard area in Hong Kong. Environ Pollut 142:512-520.

**Table 3.10 Metal contamination in sediments along the ship breaking area**

| Metals (ppm) | Sitakund of Chittagong, Bangladesh | | | Alang-Sosiya, India | Aliağa, Turkey | Bakopoulos, Greece | Standard value |
|---|---|---|---|---|---|---|---|
| | Siddiquee et al. (2009) | Hasan et al. (2013) | Field Study (2016)* | Tewari et al. (2001) | Neşer et al. (2012) | Mavrakis et al. (2004) | |
| Cd | 0.6–0.9 | 0.01–1.16 | 0.0 | 24 | 0.06–3.94 | – | 0.11[a,b] |
| Cr | 23–87 | 311–1,232 | 49.51 | – | 65.5–264 | – | 77.2[a] |
| Cu | 21–40 | 6–1,635 | 5.31 | 8 | 19.6–703 | 107–206 | 33[b] |
| Fe | 11,933–41,362 | 22,890–131,110 | 46.28 | 75,088 | 32,390–54,666 | 26,000–60,000 | 41,000[b,c] |
| Hg | 0.01–0.12 | – | 0.83 | 1.6 | 0.32–7.02 | – | 0.02[a] |
| Mn | 2–8 | 334–2,524 | 22.29 | 1488 | 283–1,192 | 1,048–2,016 | 770[c] |
| Ni | 23–49 | 8–45 | 46.96 | 117 | 27.6–240 | 75–116 | 56.1[a] |
| Pb | 37–148 | 16–22 | 17.44 | 220 | 91.3–751 | – | 19[c] |
| Zn | 84–143 | 58–978 | 1.43 | 51 | 86.4–970 | – | 95[b,c] |

(–) not measured; [a]IAEA (1989)[59]; [b]GESAMP (1982)[60]; [c]Salomons and Froster (1984)[61]
*average of values Table 3.9- South of Ship Recycling Yard + Ship Recycling yard.

**Table 3.11. Standard guideline applicable for heavy metals in marine sediment (see Sharifuzzaman et al. 2016[15])**

| Metal (µg/g) | Average crustal | Non-polluted | Moderately polluted | Heavily polluted |
|---|---|---|---|---|
| As | 1.8 | <3 | 3-8 | >8 |
| Cu | 55 | <25 | 25-50 | >50 |
| Cr | 100 | <25 | 25-75 | >75 |
| Ni | 75 | <20 | 20-50 | >50 |
| Pb | 12.5 | <40 | 40-60 | >60 |
| Zn | 70 | <90 | 90-200 | >200 |

[59]IAEA, 1989. Trace elements in marine sediments, Reference sheet SDM-2/TM. Vienna, Austria.
[60]GESAMP (IMO/FAO/IJNESCO/WMO/IAEA/UN/IJNEP), 1982. The health of the oceans. Rep. Stad. GESAMP. 15:108 and UNEP Res. Seas. Rep. Stud., 16:108.
[61]Salomons W, Forstner U, 1984. Metals in the Hydro Cycle. Springer Verlag, Berlin.

# 4 Environmental impact study

## 4.1 Field visit data

Field visits were carried out to review the sites proposed to be sampled and assess their suitability in line with the study programme.

a) Ship recycling site visits

Two ship recycling yards were visited. The scale of the operations was described, with a general walk over each site to be shown the salient features of the operations. Photographs were taken. It became apparent at this stage that valuable monitoring information had been collected, potentially for every yard. During the site walk the tide was low and significant areas of algal growth and reeds on the foreshore were observed. These would be potential subjects for investigation of metal uptake by these species.

b) Additional sampling areas

The field studies also envisage sampling of areas outside of the Sitakunda zone where ship recycling is taking place as well as streams and canals that discharge into the Bay in between the yards – there are some seven of these. In addition a reference zone (control location) deemed to be free of influence from the Sitakunda zone near to the Sandwip Island and one location in the Karnaphuli River of Chittagong port area were sampled (results are in section 3). Inspection of suitable sampling areas was carried out. In the course of this it was noted that located within and outside the recycling zone, at the shoreline are numbers of fish harvested with fixed enclosure (locally called Dhaijja fishing) and shrimp fry netting practices.

## 4.2 Secondary sources

Secondary data from the literature were surveyed to acquire and analyze statistics on physical, chemical and biological conditions of the coastal environment including basic climate data. Satellite imagery was analyzed to update land use, waterway, and erosion/accretion patterns. Finally, field observations were carried out to validate the land use measurement and also to justify accuracy of other data.

## 4.3 Limitations

With regards to the work force, the survey conducted for the study has covered ship recycling yard managers, supervisors, labour contractors, and workers through focus group discussions and semi-structured interviews. Moreover, BSBA representatives and local traders of ship-borne materials were also interviewed. The BSBA provided full support to select the yards visited but the consultants anonymously selected the above-mentioned stakeholders. Honouring the busy work schedule of the stakeholders as well as budget and time constraints, the interviews were taken in the ship recycling yards at Sitakunda.

Information about pollutant release data (predominantly metals and their concentration)in relation to ship recycling activity in Sitakunda is available including: Islam & Hossain (1986[62]), DNV (2000[63]), Siddiquee et al. (2009[64]), World Bank (2010[27]), Ahmed et al. (2013[65]), Hasan et al. (2013[66]), Islam et al. (2013[67]) and RWEC (2015[68]). Hasan et al. (2013[66]) revealed that some trace metals were found in sediments of the Sitakund Upazilla of Chittagong, Bangladesh, largely due to ship breaking activities in the area. This was seen when comparing levels of trace metals in the sediments of the study area with the recommended values of unpolluted sediments. Thus, it was inferred that the trace metal concentrations around the ship breaking area were higher than that of the control site, Sandwip, and near the Karnaphuli River mouth. The trace elements in the sediment samples were significantly correlated with one another.

However these data do not generally distinguish between the activities of ship recycling and other discharges, as discussed earlier. Studies such as modelling, comparative analysis of pollutant profiles from the range of inputs from all industries into the Bay and their transport, together with contour maps of plumes and dispersal calculations would lead to more definitive understanding of the sources of the contaminants. Especially with regards to the impact of pollutants and hazardous wastes specific to the ship recycling sector, there is no information available. Moreover, there has been a lack of systematic examination of soil, sediment, water and air samples to fully understand the environmental impact of the industry.

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[62]Islam KL, Hossain MM, 1986. Effect of ship scrapping on the soil and sea environment in the coastal area of Chittagong, Bangladesh. Marine Pollution Bulletin 17: 462-463.

[63]DNV (Det Norske Veritas), 2000. Decommissioning of ships - environmental standards; ship-breaking practices/on-site assessment; Bangladesh - Chittagong. Report 2000-3158. Oslo.

[64]Siddiquee NA, Parween S, Quddus MMA, Barua P, 2009. Heavy metal pollution in sediments at shipbreaking area of Bangladesh. Asian J Wat Environ Pollut 6:7-12.

[65]Ahmed MJ, Uddin MN, Islam MN, Islam MS, Islam MF, 2013.Physicochemical assessment of soil pollutants due to the ship breaking activities and its impact on the coastal zone of Chittagong, Bangladesh. European Chemical Bulletin 2(12): 975-980.

[66]Hasan AB, Kabir S, Reza AHMS, Zaman MN, Ahsan A, Rashid M, 2013. Enrichment factor and geo-accumulation index of trace metals in sediments of the ship breaking area of Sitakund Upazilla (Bhatiary-Kumira), Chittagong, Bangladesh. J Geochem Explor 125:130-137.

[67]Islam MN, Ahmed MJ, Hossain MA, Siraj S, 2013.Physicochemical assessment of water pollutants due to the ship breaking activities and its impact on the coastal environment of Chittagong - Bangladesh. European Chemical Bulletin 2(12): 1053-1059.

[68]RWEC, 2015.Safe and environmentally sound ship recycling in Bangladesh - Scoping Study. Roy Watkinson Environmental Consulting Ltd, RWEC/03/TC/1514-01-2320, 77 pp.

## 5 Conclusions and Recommendations

- Previous studies have shown that while marine waters and sediments at Sitakunda are contaminated with a range of substances (pollutants including heavy metals, oil, PCBs, agro-chemicals and sewage) the parameters investigated (metals, BOD, TDS) do not appear to be greatly exceeding reference values, in some but not all studies, – the reasons for this are unclear and could be due to any or all of factors relating to low release, mixing/dilution, dispersion and sampling location;

- The composition and quantities of pollutants from point and non-point sources (other than ship recycling), and their distribution in natural systems and impacts also need to be fully studied;

- Further knowledge of the effects on biota is required to be able to verify/substantiate such observations;

- An improved understanding of the environmental context of the ship recycling area at Sitakunda, in terms of the coastal marine and land environment, is required to be able to fully appreciate its potential impacts in comparison with other possible inputs from industry and agriculture etc.;

- Additional study of the range and distribution of biota over time is needed particularly to identify useful indicator species and those of local and commercial importance, including fish, shrimp crab, mollusc, and coastal plant (mangroves) species;

- An improved understanding of the separate contribution to environmental pollution made by other industry, agriculture etc. is needed to be able to differentiate this from any from ship recycling per se, especially where the same substances may be being released (e.g. heavy metals, oils );

- Further development of monitoring programmes for environmental pollution with establishment of time series measurements will help to elucidate the causes and better assess mitigation efforts.

## PART 2: ENVIRONMENTAL IMPACT ANALYSIS

### 1. Introduction

This Part is intended to indicate the issues concerning environmental pollution and its investigation with respect to ship recycling in a complex setting. It is based on the general approach used for Environmental Impact Assessments as exemplified in the Scoping Study. Therefore some contextual information is provided alongside the information developed for this element of the SENSREC project. But this Part of this report focuses on those elements comprising the environmental investigations undertaken for the SENSREC project. It is not therefore a complete EIA and some sections are deliberately not covered in any depth e.g. economic issues, hazardous waste management and occupational health and safety, in particular for sections 6-9. These latter sections serve rather as examples of the expected content and would be aligned with and supplemented by the other outputs of the Work Packages for the SENSREC project as part of a complete EIA. Results from activities described in Part 1, especially data from field studies, that supplied by the DoE from monitoring they have carried out and literature search, are also incorporated in this Part in summary form to assist in describing a wider picture and may therefore be repetitive to some degree.

### 1.1 Background to the Sitakunda ship recycling yard

Chittagong has a long and colourful history of maritime commerce that stretches back to the 4th century BCE. During this period inhabitants of Chittagong were in contact with China, Arabia, Egypt, Sumatra, the Maldives, Sri Lanka, and even East Africa. The many ports which dotted its coast rose and fell in importance as the centuries went by and were renowned for ship building. Today, however, the coastal zone of Sitakunda along the Bay of Bengal has become the focus of considerable activity and attention, not for building ships, but for recycling them.

Chittagong, particularly the Patenga, Sitakunda, Anawara, Nasirabad, Kalurghat, have rapidly become the industrialized zones in Bangladesh. The industrial belt of Chittagong, referred to as the 'Economic-Hub', (Khan 2012[69]) has reached saturation level in terms of industrial development as well as environmental degradation (Kabir et al. 2013[70], Chisty 2014[71]). Attention is now turning to the coastal and riverine environment in Chittagong. The urban Chittagong with peri-urban industrial areas supports about 6 million people with diversified professions. Hence it is pertinent that sustainable development is accorded due priority when planning for industrialization of the coastal regions in the days to come.

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[69] Khan SK, 2012. Challenges to become regional economic hub: Establishment of special economic zone (SEZ) in the port city of Chittagong. Seminar supported by the Chittagong Chamber of Commerce, BGMEA Chittagong and A.K. Khan Foundation. 7th April 2012.

[70] Kabir MH, Ismail M, Jashimuddin, M. 2013. Status of solid waste recycling at Sholokbahar Ward in Chittagong, Bangladesh. J. Environ. Sci. & Natural Resources, 6(2): 07-11.

[71] Chisty KU, 2014. Landslide in Chittagong City: A perspective on hill cutting. Journal of Bangladesh Institute of Planners, 7:1-17.

One of the first major industrial developments along the Sitakunda coast of Chittagong was the ship recycling yards where operations commenced in 1969 with the Greek ship, MD Alpine, that was beached on the shore during a storm[72]. Since the initial activity commenced ship recycling at Chittagong has grown to be of global significance. In 2014, a total of 22.76 million Gross Tons (GT) was recycled in the world. India was the biggest ship recycler with 6.79 million GT (29.8%), Bangladesh came second with 5.52 million GT (24.2%), China was third with 4.98 million GT (21.9%), Pakistan fourth with 4.09 million GT (18.0%) and Turkey fifth with 0.98 million GT (4.3%). That left only 0.40 million GT (1.8%) for the rest of the world[73].In 2015, the world total was 21.80 million. Bangladesh was the biggest ship recycler with 7.52 million GT (34.5%), Pakistan came second with 4.59 million GT (21.1%), India was third with 4.56 million GT (20.9%),China fourth with 4.04 million GT (18.5%) and Turkey fifth with 0.75 million GT (3.4%). Again, that left only 0.34 million GT (1.6%) for the rest of the world[74].

## 1.2 Objective

Previous environmental work and reporting on ship recycling activities in Bangladesh and around the world has focused mainly on the environmental problems arising within the boundaries of the ship recycling facilities. The objective of this report is to assist the ship recycling industry to become more sustainable by improving occupational safety and health working conditions and protection of the environment. The specific objectives are as follows:

a) to prepare an environmental impact analysis of the ship recycling industry in Bangladesh;
b) to review the available literature including an earlier scoping study, to produce a comprehensive up-to-date analysis of the environmental impact of the ship recycling industry;
c) to identify local environmental pressures from other potential sources as well as environmental impacts on other areas, like fishing, agriculture and aquaculture showing change over time; and
d) to conduct field work and stakeholder consultation to collect additional data to fill identified information gaps, including sampling and analysis.

The consultants made several field visits to ship recycling yards in Sitakunda and surrounding areas of industrial zones, agriculture fields, fishing areas, as well as consultation with respective stakeholders to collect data about ship recycling techniques, waste management process, environmental monitoring parameters and frequency. In addition, the team reviewed available literature including screening of relevant policy and legal documents and desk study of environmental impact analysis of the ship recycling industry.

[72]Puthucherril TG., 2010. From ship breaking to sustainable ship recycling: evolution of a legal regime. Leiden and Boston: Martinus Nijhoff.
[73]World Casualty Statistics 2014, Published by IHS Global Limited
[74] World Casualty Statistics 2015, Published by IHS Global Limited

## 1.3 Area

The area for ship recycling has remained centred in Sitakunda, which is located northwest of Chittagong city along the Bay of Bengal coast (Figure 1.1). The recycling area covers some 15 km coastline with about 100 yards, of which 30-40 yards are active.

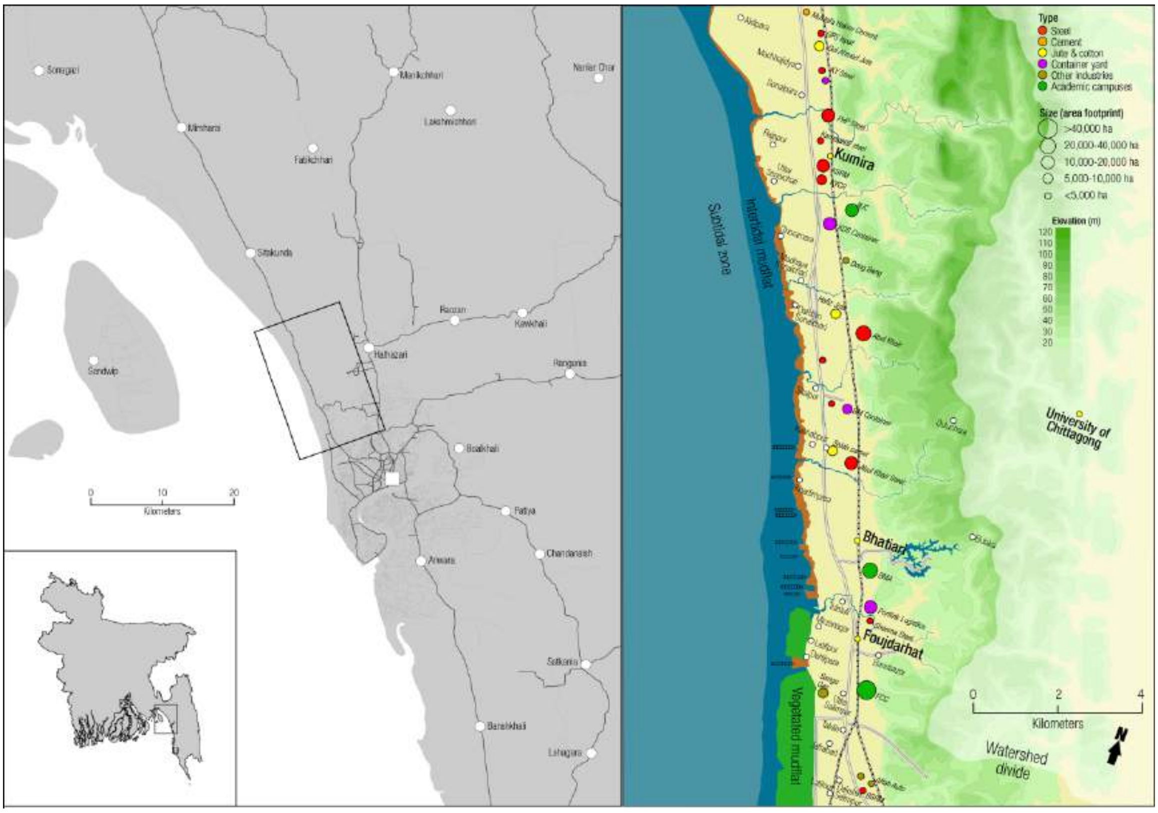


**Figure 1.1 Map showing the coastal zone of Chittagong and enlarged is the ship recycling area at Sitakunda coast**

## 1.4 Scope and limitations

The aim was to develop an understanding of environmental aspects in consideration of the ship recycling activities; especially water, sediment/soil and air quality surrounding the ship recycling yards in Sitakunda. The objective has been achieved, with the following limitations:

- The environmental conditions were mainly investigated through a mix of field and desk studies. Detailed field sampling design from designated sites within the yards and control sample beyond the nearby Sandwip Island were formulated. Contacts were made both with academic and research laboratories for subsequent analysis of the collected samples. The results of the chemical analyses are included in this report. Monitoring of some parameters is being undertaken by the Department of Environment (DoE); these data are also included in this report.

- Not all of the recycling yards were in operation as the owners do not find business always commercially viable and dismantling activities are intermittent. As understood, some of the yards have remained inactive for several years and at the same time critical coastal habitat (i.e. mangrove ecosystem) are being encroached on to establish new yards. Thus, DoE monitoring may not consistently reflect operational activity and the yards are not easily able to share data that represents this. Even so, the number of yards that permitted visits to their facilities shared data and participated in consultation meeting was satisfactory.

- Differentiation of pollutants from different sources i.e. industries, agriculture, domestic is also difficult. Ship recycling could be a minor component of environmental pollution in the area and the other sources indicated could be more significant, requiring attention to them to protect the environment.

- Thus, further studies are needed to address the issues. Some research on this at the Institute of Marine Sciences and Fisheries of the University of Chittagong is ongoing.

## 2. Policy and legal framework

### 2.1 Policy and legal consideration

Increasing industrialization and lack of waste treatment is leading to a major water pollution problem in many parts of Bangladesh, impacting on aquatic ecosystems and the population who depend on them for their livelihood activities (Ullah et al, 2006[75], Chowdhury and Clemett 2006[76]). However, Bangladesh has a well-developed set of environmental policies, Acts and Rules that deal with industrial pollution of water, soil and air.

### 2.2 Background

Bangladesh has a long legacy of environment related policies. Since the early 1980s environmental issues started drawing the attention of the policy planners in Bangladesh. The 1990s marks the beginning of the history of environmental policy in Bangladesh. The developments taking place during this decade gave a new direction to the policy concerns in the field of environment protection. This was evidenced by the *Fourth Five Year Plan(1990-1995)* which introduced a chapter on environment and sustainable development, the *Fifth Five Year Plan*(2006-2010) emphasized environment and sustainable livelihood, the *Sixth Five Year Plan*(2011-2015) focused on environment, climate change and disaster management for sustainable development. In a nutshell, the major policy initiatives, strategies and plans emphasized environment and natural resources management to achieve sustainable development. Moreover, during the last two decades much research has been carried out on environmental issues and the capacity of the government, civil society and other stakeholders has been enhanced to formulate a better environment policy for Bangladesh (Bhuyan 2010[77]).

### 2.3 Policies

#### *2.3.1 Industrial Policy 2016*

The Government of Bangladesh believes that rapid industrialization is key to the country's economic development. Given the unfavourable land-man ratio and the under-developed state of the country's agriculture sector, the key to the generation of productive employment lies in strong economic growth through the structural transformation of the economy away from agriculture and toward industry[78].

The National Industrial Policy 2016 has replaced the National Industrial Policy of 2010. The new policy has listed some industries as 'high-priority'. The priority sectors and sub-sectors will get separate investment incentives. Seven categories of industries have been included in the High Priority sectors: agriculture/food processing and agricultural

[75]Ullah ANZ, Clemett AEV, Chowdhury N, Huq T, Sultana R, Chadwick MT, 2006. Human Health and Industrial Pollution in Bangladesh. Stockholm Environment Institute, York, UK, 53 pp.

[76]Chowdhury NS, Clemett AEV, 2006. Industrial pollution and its threat to Mokesh Beel wetland in Kaliakoir. MACH (Management of Aquatic Ecosystems through Community Husbandry) technical report, Dhaka.

[77]Bhuyan AR, 2010. Bangladesh Industrial Policy 2010: A Critical Appraisal. Thoughts on Economics, 20(3): 1-16.

[78]Bhuyan AR, 2005. Industrial Policy in Bangladesh: A Survey. *Thoughts on Economics*, 15(3), July-September.

tool manufacturing industry, ready-made garments, ICT/ software, pharmaceuticals, light engineering, leather and leather products, and jute and jute goods. The policy presents an integrated strategy for achieving high economic growth in the country through rapid industrialization by means of short, medium, and long-term measures that can help raising the rate of GDP growth. The industrial policy envisages an increase in the industry sector's share in GDP from 29 to 35 percent by 2021, and seeks to raise the proportion of the workforce employed in industry to 25 percent from 18 percent by 2021.

The key features of the National Industrial Policy 2016 are:

- To expand the production base of the economy by accelerating the level of industrial investment;
- To promote the private sector to lead the growth of industrial production and investment;
- To focus the role of the government as the facilitator in creating an enabling environment for expanding private investment and sustained economic growth;
- To attract foreign direct investment in both export and domestic market oriented industries to make up for the deficient domestic investment resources, and to acquire evolving technology and gain access to export markets;
- To ensure rapid growth of industrial employment by encouraging investment in labour intensive manufacturing industries including investment in efficient small, medium and cottage industries;
- To create more scope for women entrepreneurs in industrial sectors;
- To raise industrial productivity and to move progressively to higher value added products through skill and technology upgrading;
- To enhance operational efficiency in all remaining public manufacturing enterprises through appropriate management restructuring and pursuit of market oriented policies. To diversify and rapidly increase export of manufactures;
- To ensure a process of industrialization which is environmentally sound and consistent with the resource endowment of the economy;
- To develop indigenous technology and to expand production based on domestic raw materials and inputs.

### *2.3.2 National Environmental Policy 1992*

In 1992 the National Environmental Policy (NEP) was drawn up with the aim of providing protection and sustainable management of the environment. The objectives of the Policy include:

- Maintaining the ecological balance and overall development through protection and improvement of the environment;

- Identifying and regulate polluting and environmentally degrading activities;
- Ensuring environmentally sound development;
- Ensuring sustainable and environmentally sound use of all natural resources; and
- Actively remain associated with all international environmental initiatives (MoEF1994).

### *2.3.3 National Biodiversity Strategy and Action Plan (NBSAP) 2004*

The National Biodiversity Strategy and Action Plan (NBSAP) of Bangladesh provides a framework for conservation, sustainable use and sharing the benefits of biodiversity of the country. A major focus of the NBSAP is the need for cross-sectoral linkages, reflecting the fact that in Bangladesh, more so than most other countries, biodiversity conservation is closely inter-woven with social and economic development. Thus, the NBSAP also provides a framework for securing the necessary environmental conditions to reduce poverty, ensure sustainable development and respond to the implementation of elements of the country's Poverty Reduction Strategy Paper (PRSP).

The major objectives of the NBSAP are to:

- conserve, and restore the biodiversity of the country for well-being of the present and future generations;
- ensure that long-term food, water, health and nutritional securities of the people are met through conservation of biological diversity;
- maintain and improve environmental stability for ecosystems;
- ensure preservation of the unique biological heritage of the nation for the benefit of the present and future generations;
- guarantee the safe passage and conservation of globally endangered migratory species, especially birds and mammals in the country; and
- stop introduction of invasive alien species, genetically modified organisms and living modified organisms.

This section is highly relevant to old ships being brought into Bangladesh waters, where they are potentially carrying alien plankton and microorganisms in the ballast water. Bangladesh has not yet ratified the Ballast Water Management Convention 2004, and seaports are yet to have any facilities to manage ships' ballast. The entry into force of the Ballast Water Management Convention will not only minimize the risk of invasions by alien species via ballast water, it will also provide a global level playing field for international shipping, providing clear and robust standards for the management of ballast water on ships.

### *2.3.4 National Environmental Management Action Plan (NEMAP) 1995*

The National Environmental Management Action Plan (NEMAP) was developed in 1995 as the framework of programmes and interventions aimed at implementing the NEP. NEMAP envisages identification of the key environmental issues of immediate concern for Bangladesh and the actions to halt or reduce environmental degradation, improve the natural and man-made environment, conserve biodiversity and its habitat, promote sustainable development and improve the quality indicators of human life. It was developed for a period of 10 years (1995 to 2005) and is likely to have influence in shaping policy directives regarding the environmental issues in the foreseeable future[79]. To this end, it has grouped all the relevant actions under four heads: institutional, sectoral, location specific and long-term issues.

The institutional aspects reflect the need of inter-sectoral cooperation to tackle environmental problems that need new and appropriate institutional mechanisms at national levels. The sectoral aspects reflect the way the Ministries and agencies are organized and make it easier to identify the agency to carry out the recommended actions. The location-specific aspect focuses on particularly acute environmental problems at local levels that need to be addressed on a priority basis. The long-term issues include environmental degradation of such a scale that it might become more serious and threatening than they seem to be if their cognizance is not immediately taken[80].

A National Conservation Strategy (NCS) and a National Environment Management Action Plan (NEMAP) have been formulated. Both NCS and NEMAP contain national strategies and national programs for conservation of sites important from biodiversity consideration. The Sustainable Environment Management Programme (SEMP) had a total of 26 components of which three components were directly concerned with the conservation of biodiversity in the wetlands and in the floodplains of the country through community participations[81].

## 2.4 National legislation

### *2.4.1 The Bangladesh Environment Conservation Act 1995, and Rules 1997*

The Bangladesh Environmental Conservation Act 1995, and the accompanying 1997 Rules, is arguably the most important legislative documents for industrial water pollution. The Act is dedicated to the “conservation, improvement of quality standards, and control through mitigation of pollution of the environment” (Environmental Conservation Act, 1995). The 1997 Environment Conservation Rules made in accordance with the 1995 Act provide additional guidance for specific components of the Act. The Act is enforceable by the DoE, which has responsibility for:

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[79]ADB, 2004, Country Environmental Analysis: Bangladesh .Available from: http//www.adb.org/Documents/CEAs/BAN/BAN-CEA-Jul2004.pdf.

[80] AnnualReport2006,EnvironmentforSustainableDevelopment,Departmentof Environment, Ministry of Environment and Forest, GoB, p. 8.

[81] Annual Report 2006, DoE, p. 69

- Coordinating with other authorities or agencies that have relevance to the objectives of the Act.
- Adopting safety measures and determining abatement measures to prevent accidents that may cause environmental degradation.
- Advising persons on environmentally sound use, storage, transportation, import and export of hazardous material or its components.
- Conducting research and assisting other authorities and agencies in conservation and improvement of the environment.
- Investigating locations, equipment, manufacture or other processes, ingredients, or materials, to ensure improvement of the environment, and control and mitigation of pollution.
- Collecting, publishing and disseminating information regarding environmental pollution.
- Advising the Government on manufacturing processes and materials that may cause pollution.
- Ensuring potable water quality.

In order to enforce the Act, the DoE has the right to enter, investigate, test, examine and seize, industrial plants, equipment, records, registers, documents or other significant objects, and to search places where it is believed an offence has occurred in contravention of this act.

In addition, the DoE is empowered to collect water, air, soil or other material for analysis in the presence of the occupant and under conditions laid down by the Act. Should any plant or process be found to be contravening the rules of the 1995 Act, the DoE has the power to enforce the Act through closure, prohibition or regulation of industries, initiatives or processes after due notification to the owner of the industry or process. The DoE can also initiate public hearings if an application is submitted by an individual or group of individuals who are being, or are likely to be, affected by pollution or degradation of the environment.

Since the enactment of the 1995 Act, all industrial units or projects must obtain “Environmental Clearance” from the DoE. For this purpose all industrial units and projects have been divided into four categories i.e., Green, Orange A, Orange B and Red (Schedule 1 of the Rules) depending on potential environmental impact and location. In order to obtain Environmental Clearance, industries within these categories must submit applications containing several forms of documentation. Once Environmental Clearance has been granted it is valid for a period of 3 years for Green Category industries and 1 year for all other Categories. Applications for renewal must be made 30 days before expiry. Ship recycling industry is classified in Orange B category, which requires it to have an Environmental Management Plan and ETP.

## 2.5 Other legislation

### *2.5.1 The Ship Breaking and Ship Recycling Rules 2011*

The Ship Breaking and Ship Recycling Rules 2011 have been developed for safe and environmentally sound ship recycling in Bangladesh. The Ship Building and Ship Recycling Board (SBSRB) is established by these rules and, when in place, it will be the Government one stop service provider under the Ministry of Industries. It will provide integrated service for ship breaking, recycling and other related activities.

Under these rules:

To import a ship for breaking and recycling the yard owner has to obtain the NOC (No Objection Certificate) from SBSRB by submitting a yard environment clearance certificate, ship's details of particulars, MOU with buyer and the Inventory of Hazardous Materials on board. To open the letter of credit from any scheduled bank it will require the NOC from SBSRB. In cooperation with the SBSRB the Department of Environment simultaneously examines the ship for Hazardous Waste and material excluding in-built hazardous and toxic materials and they may issue an environment clearance certificate for that particular ship. Similarly, the SBSRB and the Department of Explosives issues the certificates for 'Gas free for man entry' and 'Gas free for hot work', which means that the ship can be cut by torches.

Ship recycling is the process of dismantling a vessel's structure or disposal conducted at a recycling facility for dismantling a ship. It includes a wide range of activities, from removing all gears and equipment to cutting down and recycling the ship's infrastructure. Before providing demolition or cutting permission, the yard owner has to submit a Ship Recycling Plan (SRP) and copy of the permit for Ship Recycling Facility Plan (SRFP). The SBSRB is the authority designated to ensure compliance with all ship breaking rules and regulations. It also oversees hazardous waste/materials generation and its disposal. Non-compliance of rules will result in the cancellation of the permit. The ship recycler can get a new permit only after a full re-inspection of corrective measures. The SBSRB in future will conduct its monitoring activities half yearly. It may conduct more inspections when accidents take place.

### *2.5.2 Bangladesh Ship Recycling Act 2016*

Bangladesh Ship Recycling Act 2016 (subject to legal vetting procedures at the time of this report) is aimed at setting up the industry in a certain area considering environmental impacts as well as regulating the activities of the fast growing industry. The government will set up one or more zones for the industry. The entrepreneurs will set up yards in the designated zone. Penalties will be imposed for setting up yards outside the zone. Bangladesh Ship Recycling Board will be formed, headed by a Chairman and a full time Director General, as a regulatory authority. The Board will facilitate a 'One-Stop Service' for discharging the day-to-day administrative tasks with regard to the ship recycling activities, for example issuance of No Objection Certificate, Inspection Order, Beaching permission, Cutting permission, etc.

## 3. Overview of the ship recycling industry

### 3.1 Description of the industry

The global ship recycling industry dismantles yearly about 1250 large ocean-going vessels to recover steel and other valuable metals or recyclable items. Nearly all ship recycling activities are concentrated in five countries namely, India, Bangladesh, Pakistan, China, and Turkey. Consequently, South Asia is undoubtedly the global centre for ship recycling. Three main business stakeholders determine the fate of the global ship recycling industry, market developments and practices. First, the ship owners decide when to sell a ship for recycling and the price at which they want to sell it. Secondly, cash buyers (sometimes also brokers) identify a ship recycling facility for the ship owner. Finally, the ship recycling or ship recycling yards, (who need to implement the standards for the dismantling activities), break the ship and send the disassembled parts for recycling and/or reuse.

Ship recycling activity began in Bangladesh during 1960s and has since employed the beaching method. During the 1980s, there were 30 companies involved in the recycling industry and the number has grown to more than 100 in recent years. Ship recycling activities taking place here represent the second/third largest facility in the world with respect to the numbers of vessels being scrapped due to higher tidal range, suitable intertidal zone for beaching large vessels, cheap labour and slack environmental regulations (Alam and Faruque 2014[5]). It is a challenging process, due to the structural complexity of the ships and the involvement of environmental, safety, and health issues. Although steel is recycled, any uncontained toxic substances released would contaminate the environment. It has been reported that large amounts of hazardous materials are likely to accumulate in Bangladesh if the prevailing practices continue over the next 20 years.

### 3.2 Type and category of industry

Industries in Bangladesh are classified according to their potential impact on the environment into four categories: Green, Orange-A, Orange-B, and Red. Green industries are automatically granted a clearance certificate. Orange categories must submit further information and plans, and may be subject to field inspection. Highly polluting categories, Orange-B and Red, must in addition conduct a detailed Environmental Impact Assessment (EIA) and prepare Environmental Management Plans (EMP) satisfactory to the Department of Environment (DoE). The DoE is understood to have categorized ship breaking activities as Orange-B.

### 3.3 Site description

The ship recycling yards are located in the Sitakund coast, along the northern part of Chittagong district. The Dhaka-Chittagong highway (known as the Asian highway) and the railway pass over this area. Moreover, local feeder roads are well developed and suitable for running vehicles throughout the year that are also connected with the Asian highway. The total area supports hilly streams, Sandwip channel, accreted mud flats, wet meadows, mangrove ecosystem, plain land, hills and hillocks. The upland area is used for cultivation and human settlement. The hill bottom alluvial land system extends up to the tidal alluvial land and Sandwip Channel. Tidal alluvial land is located at the western part of Sitakunda. Due to the presence of coastal embankment this land usually is not flooded but in the rainy season inundation may occur in comparatively low-lying lands and lasts for two to three months.

A total of 7 streams (locally called khal) have originated from the nearby hills and flow in an east-west direction around and through the ship recycling zones and empty into the Bay of Bengal. The streams are tidally influenced but mostly there is little flow during the dry season. The Sandwip channel is a busy navigational route as well as fishing zone among the local community. Tremendous growth of natural grass has been used for wet meadows (buffalos, cows and goats) along the coast.

Areas of natural beauty are also found such as the BMA Lake within the Bangladesh Military Academy campus and waterfalls namely Shasradhara and Suptadhara in Chandranath reserve forest with high tourism value. A coastal afforestation program in the Sitakunda Forest Range under Chittagong Coastal Afforestation Division was started in 1968 within a few kilometers on both ends of the ship recycling zone. The width of mangrove plantation ranged between 1000-3000 m across the coast with *Sonneratiaapetala* (keora), *Avicennia officinalis* (baen), *Excoecariaagallocha* (gewa), *Ceriopsdecandra* (goran) and *Bruguierasexangula* (kakra). Mangrove clearance has been carried out to establish ship recycling yards at Sitakunda coast (Abdullah et al. 2013[19]). This may be confirmed by time series analysis of high resolution satellite imagery and ground truthing. (The productive and protective roles of mangrove are included in Figure 2.2 of Part 1).The geo-spatial distribution of mangroves along Bangladesh coast, suitable accreted stable coastal lands for mangrove afforestation as well as importance of mangroves with main causes of mangrove destruction have been addressed by many authors (Hossain and Lin 2001[82], Hossain et al. 2003[83], Hossain et al. 2009[84], Chowdhury et al. 2011[85], Rahman and Hossain 2012[86], Hossain 2013[87]).

[82]Hossain MS, Lin CK, 2001. Land Use Zoning for Integrated Coastal Zone Management: Remote Sensing, GIS and RRA Approach in Cox's Bazar Coast, Bangladesh. *ITCZM Publication Series*, No.3, Asian Institute of Technology, Thailand, 25 pp.

[83]Hossain MS, Lin CK, Tokunaga M, Hussain MZ, 2003.Remote Sensing and GIS application for suitable mangrove afforestation area selection in the coastal zone of Bangladesh. *Geocarto International*, Vol. 18, No. 1: 61-65.

[84]Hossain MS, Wong S, Chowdhury MZR, Shamsuddoha M, 2009.Remote Sensing and GIS Application to Mangrove Forest Mapping in the Meghna Deltaic Islands of Bangladesh. *Bangladesh Journal of Marine Sciences and Fisheries*, 1(1): 81-96.

[85]Chowdhury MSN, Hossain MS, Mitra A, Barua P, 2011. Environmental functions of the Teknaf Peninsula mangroves of Bangladesh to communicate the values of goods and services. *Mesopotamia Journal of Marine Science*, 26 (1): 79 - 97.

[86]Rahman M, Hossain MS, 2012. Mangrove forests and aquaculture farmers: Aspects of climate change adaptation on the central coast of Bangladesh. *World Aquaculture*, 45(1): 12-16.

[87]Hossain MS, 2013.Conserving Mangrove Ecosystem for Climate Change Adaptation in the Ganges Basin. In: Moksness, E., Dahl, E and Stottup, J (eds.), Global challenges in integrated coastal zone Management. Wiley-Blackwell, UK, 85-100 p.

Annual rainfall in Sitakunda was 2334-3985 mm and maximum annual temperature was 29.45-31.80°C during 1980-2010. Southwest monsoon air provides about 90% of the total rainfall. Occasional thunderstorms, cyclones and storm surges occur during monsoon season. The winter season (November-February) is characterized by dry, cool and sunny weather with occasional raining.

### 3.4 Project activity

The Safe and Environmentally Sound Ship Recycling (SENSREC) project in Bangladesh is designed to enhance the development of safe and environmentally sound ship recycling in Chittagong, Bangladesh. Major activities of Work Package 1 of the SENSREC project are as follows:

- Undertake an initial review of scientific literature including scoping study report to define the programme of work for the environmental impact study;
- Arrange and attend the inception meeting in Chittagong Bangladesh with the full team of consultants in order to plan, manage and allocate the contributions and responsibilities of the team members;
- Attend ship recycling yards and surrounding sites visit for participatory survey, focus group discussions, semi-structured interviews to collect required data;
- Utilization of communication strategy i.e. email correspondence, skype meeting to ensure effective cooperation and coordination among the team members of the different inputs;
- Preparation of detailed and up-to-date land use map of the study area indicating geo-spatial distribution of ship yards, industries, settlement, croplands, waterways and road networks;
- Assess the results of the field work and review all data for compilation into the report;
- Compilation and preparation of the report, addressing recommendations and specifications set out in the scoping report; edit/revise and update the report.

# 4. Baseline environment

## 4.1 General consideration

Ship recycling at Sitakunda is located within a complex zone of coastal, urban and rural land-based environments. There are major river discharges (from the Feni River in the north, and the Karnaphuli and Sangu in the south) into the Bay of Bengal close to the ship recycling zone along with diurnal tidal influences on the shoreline. Moreover, other water systems (streams) from the nearby hills and discharges of effluents, agro-chemicals, sewage and wastewater from industrial, agricultural and residential sources make their inputs to the bay. Ship recycling is not therefore an isolated activity.

## 4.2 Physico-chemical environment

### *4.2.1 Land and land use patterns*

Sitakunda Upazila is some 484 $km^2$, with forests cover approximately 13% (62 $km^2$) of this land area. Agriculture represents the predominant land use and major part of the local economy. Out of 121 $km^2$ (12,141 hectares) of cultivable land 25% yield a single crop, 58% yield double and 17% a treble crop annually (SRDI 1990[88]). Among the other land use types, ship recycling yards have expanded from about 3 km (1,500 hectares) in 1989 to nearly 15 km in 2014 (Abdullah et al. 2013[19]; Sharifuzzaman et al. 2016[15]). The use of land for industrial purposes includes cement factory, container depots, re-rolling mills, jute and textile mills, etc. (source: Banglapedia; Wikipedia[89]).

### *4.2.2 Topography, Soil & Geology*

The geomorphology of the area can be divided into five categories due to the difference of land formation. Hills in the Sitakunda coastal belt extend from northwest to southeast. These hills are of two types namely moderately high (10-100m.) and low hills/hillocks (<10 m.). The highest peak of Chittagong is Chandranath in Sitakunda 329m above sea level. Soil erosion and landslides are a common phenomenon in the rainy season in these hills. The valleys are scattered in the hilly areas. Most of the valleys are almost plain high land that does not flood during rainy season but may create water logging due to sudden hillside drainage. Almost the entire area is used for cultivation and human settlement. The hill bottom alluvial land system starting from the hill bottom extends up to the western tidal alluvial land and Sandwip channel. Tidal alluvial land is located at the western part of Sitakunda. Due to the presence of coastal embankment this land usually does not flood but in the rainy season inundation may occur in comparatively low-lying lands and lasts for two to three months.

[88] SRDI,1990. Land and Soil Resources user guide, Sitakunda Thana (in Bangla), Soil Resources Development Institute (SRDI), Ministry of Agriculture, Dhaka 83 pp.

[89] Banglapedia. Sitakunda Upazila. http://en.banglapedia.org/index.php?title=Sitakunda_Upazila, retrieved 03/05/2016.Wikipedia.SitakundaUpazila. https://en.wikipedia.org/wiki/Sitakunda_Upazila, retrieved 03/05/2016.

### 4.2.3 *Hydrology and hydrography*

A total of 7 streams (locally called khal) have originated from the nearby hills and flow in an east-west direction through the ship recycling zones and empty into the Bay of Bengal. The streams are tidally influenced but mostly become dry during the dry season. The Sandwip channel is a busy navigational route as well as a fishing zone among the local community. The BMA Lake within Bangladesh Military Academy campus and waterfalls, Shasradhara and Suptadhara in Chandranath reserve forest, possesses natural scenic beauty and aesthetic value that attracts tourism.

The coast is tidally influenced all year. Tides are semi-diurnal with two high and two low waters during a lunar day. Tidal behaviour varies along the coast in terms of magnitude but not of pattern. The tide ranges from 0.07 m during neap tide to 4.42 m during spring tide. There is a pronounced seasonal sea level variation. The sea level is highest during the south-west monsoon and lowest in the winter. Extreme set-ups occur during cyclones, where the storm surge can reach 5-7 m. The main, large scale circulation in the marine water of Bangladesh is of clockwise and anti-clockwise rotation, wind driven waves running up the coast often throwing large numbers of organisms on to the beach. Wave heights vary from 0 to 4 metres.

The dominant soil characteristics include muddy and sandy-clay texture (Hossain et al. 2009[90]). Ebb and flood tidal current, and their influence on suspended sediment flux are reported for the Salimpur coast, Chittagong (Nabi et al. 2011[16]) but microscale eddies, gyres and drifts have not been studied anywhere in Bangladesh coast.

### 4.2.4 *Marine waters and sediment quality*

In general, ship recycling activities can give rise to releases that contribute to pollution of coastal soil and seawater environment at a local scale (i.e. surrounding the yard sites, from Fouzdarhat to Kumira). Nearby (such as Baroaoliar Mazar at north, the Karnaphuli river mouth at east) or distant (such as Sandwip Island) areas have reported lower levels of contaminants (Islam & Hossain 1986[91]; Khan & Khan 2003[92]; Hasan et al. 2013b[93]) (see Figure 3.8). In particular, levels of pH, dissolved oxygen (DO) and biochemical oxygen demand

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[90] Hossain MS, Wong S, Chowdhury MZR, Shamsuddoha M, 2009. Remote Sensing and GIS Application to Mangrove Forest Mapping in the Meghna Deltaic Islands of Bangladesh. *Bangladesh Journal of Marine Sciences and Fisheries*, 1(1): 81-96.

[91] Islam KL, Hossain MM, 1986. Effect of ship scrapping activities on the soil and sea environment in the coastal area of Chittagong, Bangladesh. Marine Pollution Bulletin 17: 462-463.

[92] Khan MAA, Khan YSA, 2003. Trace metals in littoral sediments from the north east coast of the Bay of Bengal along the ship-breaking area, Chittagong, Bangladesh. Journal of Biological Sciences 3: 1050-1057.

[93] Hasan AB, Kabir S, Reza AHMS, Zaman MN, Ahsan A, Rashid M, 2013b. Enrichment factor and geo-accumulation index of trace metals in sediments of the ship breaking area of Sitakund Upazilla (Bhatiary-Kumira), Chittagong, Bangladesh. Journal of Geochemical Exploration 125: 130-137.

(BOD) fall within a normal range conducive for protection and propagation of aquatic species, and sustaining a natural eco-system (Table 4.1).

A few studies have investigated metals in the seawater of the ship recycling area, extending from Bhatiary to Kumira (Figure 4.1), between 2011 and2012. The results suggested that levels of heavy metals (mg/L) such as Cd (0.024–0.037) and Pb (0.01–0.35) in water are within standard limits (with reference to USEPA water quality guidelines) (see Hasan et al. 2013a, Islam et al. 2013 in Figure 4.1). (Cd: 0.033; Pb: 0.21), but Hg level (0.82–2.44) is elevated compared to the standard (<0.01) as noted in one study (Table 4.2). Moreover, a recent study considered Khejurtolighat (for metals Hg, Cd, Pb, Zn, and Cr) and Salimpur (for Cd) sites of Sitakunda coast as the hotspots of metal contamination (BOBLME 2015[94]).

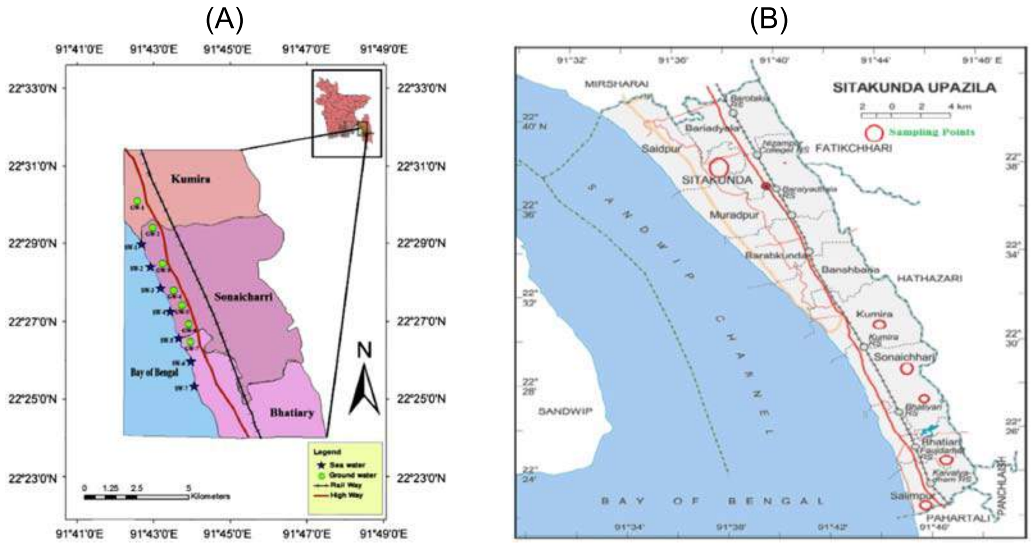


**Figure 4.1. Maps showing the sample collection points of seawater analyses carried out by (A) Hasan et al. (2013a[95]) and (B) Islam et al. (2013)[96].**

[94]BOBLME, 2015. Pollution monitoring in rivers, estuaries and coastal areas of Bangladesh with Artificial Mussel (AM) technology. BOBLME-2015-Ecology-30, 54 pp.

[95]Hasan AB, Kabir S, Selim Reza AH, Zaman MN, Ahsan MA, Akbor MA, Rashid MM, 2013a. Trace metals pollution in seawater and groundwater in the ship breaking area of Sitakund Upazilla, Chittagong, Bangladesh. Marine Pollution Bulletin 71: 317–324.

[96]Islam MN, Ahmed MJ, Hossain MA, Siraj S,2013.Physicochemical assessment of water pollutants due to the ship breaking activities and its impact on the coastal environment of Chittagong - Bangladesh. European Chemical Bulletin 2(12): 1053–1059.

**Table 4.1 Physico-chemical properties of seawater in the ship recycling area at Sitakunda Chittagong**

| Parameter | Within/around shipyard | | | [1]Away from shipyard | *Standard level |
|---|---|---|---|---|---|
| | Islam & Hossain (1986) | Hasan et al. (2013a) | Islam et al. (2013) | Islam & Hossain (1986) | |
| Turbidity (JTU) | 690–723 | – | – | 470–475 | 30 NTU |
| TS (mg/l) | 3678–4195 | – | – | 2284–2335 | – |
| TDS (mg/l) | 1860–1990 | – | 9370–17740 | 1288–1320 | – |
| pH | 7.7–7.9 | – | 6.79–8.22 | 7.2–7.3 | 6.5–8.5 |
| EC (µs/cm) | 1600–1860 | – | 15940–32500 | 3036–3040 | – |
| DO (mg/l) | 3.70–4.10 | – | 3.01–6.89 | 6.20–6.36 | >3.5; 5.0 |
| BOD (mg/l) | 6.98–7.90 | – | 0.51–3.17 | 4.08–4.30 | 3–5 |
| COD (mg/l) | – | – | 178–338 | – | |
| Ammonia (mg/l) | 2.67–3.16 | – | – | 0.20–0.26 | 0.07–0.1 |
| $NO_3$ (mg/l) | – | bdl–29.7 | 0.26–0.78 | – | 0.02–0.06 |
| $PO_4$ (mg/l) | – | – | 1.06–2.18 | – | 0.015–0.045 |
| $SO_4$ (mg/l) | – | 1764–2331 | 540–609 | – | – |
| Chloride (mg/l) | 460–502 | 8857–14443 | 10139–21536 | 785–789 | – |
| Iron (mg/l) | 36.02–41.26 | 0.33–160.5 | 19.02–33.40 | 2.26–2.80 | <0.3 |
| Oil (mg/l) | 9280–10800 | – | – | – | ** |

(–) not measured; bdl: below detection limit; JTU: Jackson Turbidity Unit; NTU: Nephelo Turbidity Unit; **Not visible to naked eye;
[1]BaroaoliarMazaris located on the north side of ship recycling yards; *Recommended seawater quality criteria by US EPA, Water Quality Management Bureau (Thailand) and Maharashtra Pollution Control Board (India)

**Table 4.2 Concentrations of heavy metals in the water of ship recycling area**

| Metal (mg/l) | Ship recycling area | | *Standard level |
|---|---|---|---|
| | Hasan et al. (2013a) | Islam et al. (2013) | |
| Cd | 0.003–0.004 | 0.024–0.037 | 0.033 |
| Hg | 0.82–2.44 | – | <0.01 |
| Pb | 0.01–0.35 | 0.02–0.04 | 0.21 |
| Co | – | 0.02–0.08 | – |
| Cr | 0.01–0.21 | 0.05–0.35 | 1.1 |
| Cu | 0.01–0.93 | 0.02–0.15 | <0.008 |
| Al | 0.02–84.25 | – | – |
| Mn | 0.06–2.20 | 1.21–2.65 | <0.1 |
| Ni | 0.01–0.48 | 0.01–0.05 | 0.074 |
| Zn | 0.03–2.7 | 0.35–0.87 | 0.09 |
| As | 0.005–0.080 | 0.010–0.951 | 0.069 |

(–) not measured; *Recommended seawater quality criteria by US EPA and Maharashtra Pollution Control Board (India)

*Water quality summary:*

Abnormal (i.e. too high or too low levels) changes in physicochemical parameter(s) of water not only affect aquatic life forms (such as fish, invertebrates, bacteria and plants) but also the surrounding ecosystem. As such water quality is an important part of environmental monitoring. Table 4.3 shows summary data from laboratory analysis from field studies carried out for this report and data supplied by DoE compared with previous literature reports and Bangladesh Environmental Conservation Rules (ECR1997). Among the important water quality parameters, the data for temperature (31°C), pH (~7.5–8.0), DO (5.0–10.0 mg/l) and BOD (5.72 mg/l), obtained, were found to be within the acceptable standard of ECR1997. But COD levels in the waters of ship recycling yards, as revealed by current (258–366 mg/l) and previous (178–338 mg/l) studies, were higher than the ECR1997 standard (200 mg/l). An escalated COD concentration is most likely due to the presence of high amount of oil & grease (81.0 mg/l; field study result). Zhang et al. (2014[97]) found that COD concentration in water was decreased with the decrease of oil concentration, and thus COD is reported to be positively correlated with oil concentration. From the field study values (i.e. 2.20 mg/l), levels of TDS in other studies (7,966–17,740 mg/l) were much higher compared to the ECR 1997 standard of 2100 mg/l. In this case, ECR standard has limitations as it is only applicable to estuarine environment, but not to coastal and marine waters. Moreover, precipitation in the months of July-September is reported to lower the salinity levels of entire coastal Bangladesh to zero and thus influencing the TDS levels as observed in field study results. The dissolved solids concentration, commonly called the water's salinity, is classified as fresh: 0–1,000 mg/l; slightly saline: 1,000–3,000 mg/l; moderately saline: 3,000–10,000 mg/l; very saline: 10,000–35,000 mg/l; and briny: >35,000 mg/l (Heath 1983[98]).

[97] Zhang J, Shao M-H, Dong H, 2014. Degradation of oil pollution in seawater by bipolar electro-fenton process. Pol. J. Environ. Stud. 23(3): 933-941.

[98] Heath RC, 1983. Basic ground-water hydrology: U.S. Geological Survey water supply paper 2220, p. 84.

Iron (Fe) levels in the water of ship recycling yards were lower (0.08 ppm or mg/l; field study result) than the ECR standard (2.0 mg/l), although previous studies recorded much higher concentrations, e.g. 36.02–41.26 mg/l (Islam and Hossain 1986[99]), 0.33–160.5 mg/l (Hasan et al. 2013a[95]) and 19.02–33.40 mg/l (Islam et al. 2013[96]), respectively.

**Table 4.3: Comparison of some physicochemical parameters of water of ship recycling yards, Sitakunda**

| **Parameter** | **Current study results** | | **Previous study (Islam et al. 2013)** | **Standard (ECR 1997)** |
|---|---|---|---|---|
| | DoE | Field study | | |
| Temperature (°C) | – | 31 | – | 40–45 |
| pH | 7.66–7.88 | 7.53 | 6.79–8.22 | 6.0–9.0 |
| DO (mg/l) | 5.3–5.7 | 10.0 | 3.01–8.22 | 4.5–8.0 |
| BOD (mg/l) | – | 5.72 | 0.51–3.17 | 50 ($BOD_5$ at 20°C) |
| COD (mg/l) | 258–366 | – | 178–338 | 200 |
| TDS (mg/l) | 7,966–12,431 | 2.20 | 9,370–17,740 | 2100 |
| Oil & grease (mg/l) | 5.2–6.1 | 81.0 | – | 10 |

According to the current field and previous study results, heavy metals such as cadmium (Cd), mercury (Hg) and lead (Pb) in the water of ship recycling yards were also below the standards of ECR (1997). However, Hasan et al. (2013a[95]) reported elevated levels of Hg (0.82–2.44 mg/l) that exceeded ECR standard (0.01 mg/l), (Table 4.4).The analysis results (by DoE, field study and previous reports) of other metals such as As (except 0.010–0.951 mg/l by Islam et al. 2013[96]; ECR standard 0.2 mg/l), Cr, Cu, Mn, Ni and Zn in water were below the ECR standard.

**Table 4.4: Cadmium, mercury and lead in the water of ship recycling yards, Sitakunda**

| **Metal (ppm or mg/l)** | **Field study result** | **Previous study** | | **Standard (ECR, 1997)** |
|---|---|---|---|---|
| | | Hasan et al. (2013a) | Islam et al. (2013) | |
| Cd | 0.0007 | 0.003–0.004 | 0.024–0.037 | 0.05 |
| Hg | <0.001 | 0.82–2.44 | – | 0.01 |
| Pb | 0.01 | 0.01–0.35 | 0.02–0.04 | 0.1 |

*Sediment quality*

Data on sediments at ship recycling yards is shown in tables 4.5–4.8 compared with standard values. While there is some variation mercury (Hg) is within the standard limit but the levels of Cd and Pb are higher (Table 4.5).Their levels in sediment are not so significant in the ship recycling area as to be considered polluted in comparison with USEPA sediment quality guidelines (Table 4.6).In fact, the levels of Cd and Pb in the sediment from field study results, (Table 4.8) are inside the threshold effects level (TEL), below which adverse biological effects are not expected to occur (Table 4.7).

[99]Islam KL, Hossain MM, 1986. Effect of ship scrapping activities on the soil and sea environment in the coastal area of Chittagong, Bangladesh. Marine Pollution Bulletin 17: 462-463.

For comparison Mavrakis et al. (2004) [100] reported much higher average concentrations (µg/g) of Cu (319–898), Fe (34–74), Mn (733–6560) and Ni (98–126) in the sediments of Skaramaga (Greece) ship yards than those measured at a remote sampling point (i.e. Cu = 44–351; Fe = 2429; Mn = 399–1308; Ni = 84–112). The authors concluded that coastal sediment linked to shipyards and scrap metal yards tend to hold nearly double the quantity of heavy metals contamination compared to the centre of the gulf/bay. Moreover, Sany et al. (2013) [101] investigated temporal and spatial distribution of heavy metals in sediments of Port Klang (Malaysia) and observed significantly higher concentrations (µg/g) of As (34.1–112.8), Cd (0.28–1.55), Hg (0.17–0.35) and Pb (47.5–85.9) than that of background levels. Main sources of metal contamination in Port Klang were industrial wastewater from cement manufacturing, oil/electrical-based power generation, palm oil, port activities (e.g. boat docking and corrosion of ships), and agricultural activities such as application of organic insecticides (lead-arsenate), pesticides, fertilizers.

The data on polycyclic aromatic hydrocarbons (PAHs), Tributyltin (TBT) and polychlorinated biphenyl (PCB) for water in the ship recycling area are limited. TBT, which is an active biocide in antifouling paints and was originally designed for use on the hulls of ship to prevent the attachment of barnacles (Hossain 2001[102]), in the range of 0.47 to 3 ng/g have been observed in silurid catfish (*Wallago attu*), catla (*Carla carla*), hilsa (*Hilshailisha*) and aor (*Mystusaor*) from Dhaka, Bangladesh. But even this result is comparatively lower than those reported for Japan, Canada and the USA. The exposure to TBT in the region may potentially link to ship recycling activities, sewage disposal and anti-foulant sources (Kannan et al. 1995[103]). DNV (2000) reported TBT levels of 17–25 mg/kg in soil from a steel plate manufacturing site located near ship recycling area. This level is lower than the maximum levels in marine sediments (26.3 mg/kg) reported by WHO in 1990[104]. With the average seafood consumption for different countries (FAO 1998[105]), the TARL was calculated for each country for which TBT data were found. Both the average seafood consumption and the TARL are shown in Table 4.9.

[100] Mavrakis A, Theoharatos G, Asimakopoulos DN, Christides A,2004. Distribution of trace metals in the sediments of Elefsis Gulf. Mediterranean Marine Science 5:151-158.
[101] Sany SBT, Salleh A, Sulaiman AH, Sasekumar A, Rezayi M, Tehrani GM,2013.Heavy metal contamination in water and sediment of the Port Klang coastal area, Selangor, Malaysia. Environmental Earth Sciences 69:2013-2025.
[102] Hossain MS, 2001. Effects of tributyltin antifouling paints on coastal ecosystems. *INFOFISH International*, May/June, Number 3/2001: 55-56.
[103] Kannan K, Tanabe S, Iwata H, Tatsukawa R, 1995. Butyltins in muscle and liver of fish collected from certain Asian and Oceanian countries. Environmental Pollution 90: 279-290.
[104] WHO, 1990. Tributyltin compounds. Environmental Health Criteria, Vol. 116, Geneva.
[105] FAO, 1998. Food Balance Sheet 1996. Product Fish, Seafood. http://apps.fao.org/lim500/nph-wrap.pl? Food Balance Sheet & Domain=Food Balance Sheet.

**Table 4.5Degree of metal contamination in sediments along the ship recycling area**

| Metal (µg/g)* | Ship recycling area | | | | | Standard value |
|---|---|---|---|---|---|---|
| | DNV (2000) | Khan & Khan (2003) | Siddiquee et al. (2009) | Ahmed et al. (2013) | Hasan et al. (2013b) | |
| Cd | bdl | 0.61–1.38 | 0.6–0.9 | 0.55–3.95 | 0.01–1.16 | 0.11[a,b] |
| Hg | 0.022–0.052 | – | 0.01–0.12 | – | – | 0.02[a] |
| Pb | 13–25 | 21–25 | 37–148 | bdl–137 | 16–22 | 19[c] |
| Cu | 27–93 | 26–40 | 21–40 | bdl–296 | 6–1635 | 33[b] |
| Cr | 41–66 | 73–83 | 23–87 | 0.6–65 | 311–1232 | 77.2[a] |
| Fe | 21803–30516 | 4364–5917 | 11933–41362 | 1250–10057 | 22890–131110 | 41000[b,c] |
| Mn | 499–738 | 544–570 | 2–8 | bdl–159 | 334–2524 | 770[c] |
| Ni | 41–63 | – | 23–49 | 16–162 | 8–45 | 56.1[a] |
| Zn | 67–172 | 32–36 | 84–143 | 33–305 | 58–978 | 95[b,c] |

*or ppm; bdl: below detection limit; (–) not measured; [a]IAEA (1989)[59]; [b]GESAMP (1982)[60]; [c]Salomons&Froster (1984)[61]

**Table 4.6 Sediment quality guideline (SQG) by US EPA**

| Metal | Sediment quality (µg/g) | | | |
|---|---|---|---|---|
| | Average crustal | Non-polluted | Moderately polluted | Heavily polluted |
| As | 1.8 | <3 | 3–8 | >8 |
| Cu | 55 | <25 | 25–50 | >50 |
| Cr | 100 | <25 | 25–75 | >75 |
| Ni | 75 | <20 | 20–50 | >50 |
| Pb | 12.5 | <40 | 40–60 | >60 |
| Zn | 70 | <90 | 90–200 | >200 |

Source: Perin et al. (1997)[106],Pazi (2011)[107]

[106]Perin G, Bonardi M, Fabris R, Simoncini B, Manente S, Tosi L, et al. (1997) Heavy metal pollution in central Venice lagoon bottom sediments: Evaluation of the metal bioavailability by geochemical speciation procedure. Environment and Technology 18: 593–604.

[107]Pazi I, 2011. Assessment of heavy metal contamination in Candarli Gulf sediment, Eastern Aegean Sea. Environmental Monitoring and Assessment 174: 199-208.

**Table 4.7 Sediment quality guideline (SQG) for heavy metals in marine sediments**

| SQGs | Metals concentration (μg/g) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | As | Cu | Cr | Cd | Ni | Pb | Hg | Zn |
| TEL | 7.2 | 18.7 | 52 | 0.68 | 15.9 | 30.2 | 0.13 | 124 |
| PEL | 41.6 | 108 | 160 | 4.2 | 42.8 | 112 | 0.7 | 271 |
| ERL | 8.2 | 34 | 81 | 1.2 | 21 | 47 | 0.15 | 150 |
| ERM | 70 | 270 | 370 | 9.6 | 52 | 218 | 0.71 | 410 |

TEL: threshold effects level, below which adverse biological effects are not expected to occur
PEL: probable effects level, above which adverse biological effects are expected to occur
ERL: effects range-low
ERM: effects range-medium
Adapted from Grecco et al. (2011)[108], Hu et al. (2013)[109], Dimitrakakis et al. (2014)[110]

[108]Grecco LE, Gómez EA, Botté SE, Marcos AO, Marcovecchio JE, Cuadrado DG, 2011. Natural and anthropogenic heavy metals in estuarine cohesive sediments: geochemistry and bioavailability. Ocean Dynamics 61:285-293.

[109]Hu B, Li J, Zhao J, Yang J, Bai F, Dou Y, 2013. Heavy metal in surface sediments of the Liaodong Bay, Bohai Sea: distribution, contamination, and sources. Environmental Monitoring and Assessment 185: 5071-5083.

[110]Dimitrakakis E, Hahladakis J, Gidarakos E, 2014. The “Sea Diamond” shipwreck: environmental impact assessment in the water column and sediments of the wreck area. International Journal of Environmental Science and Technology 11: 1421-1432.

*Sediment quality summary:*
As noted in field study results, the levels of Cd (0.0 mg/l) and Pb (18.72 mg/l) in sediments of ship recycling yards were found within recommended standards, (i.e. Cd: 0.11 mg/l and Pb: 19 mg/L). But, studies of Siddiquee et al. (2009)[111], Ahmed et al. (2013[65]) and Hasan et al. (2013b[93]) reported higher levels of Cd and Pb than standard (Table 4.8). Compared to standard (0.02 mg/l), Hg level was high (1.6 mg/l) in field study result, although the study by Siddiquee et al. (2009)[111] noted much lower levels, i.e. 0.01–0.12 mg/l. The other metals, such as Cr, Cu, Fe, Mn, Ni and Zn, in sediments of field study result were also found lower than standard.

**Table 4.8: Cadmium, mercury and lead in the sediment of ship recycling yards, Sitakunda, Chittagong**

| **Metal (ppm or mg/l)** | **Field study result** | **Previous study** | | | **Guideline limits** |
|---|---|---|---|---|---|
| | | A | B | C | |
| Cd | 0.00 | 0.6–0.9 | 0.55–3.95 | 0.01–1.16 | 0.11[a,b] |
| Hg | 1.6 | 0.01–0.12 | – | – | 0.02[a] |
| Pb | 18.72 | 37–148 | bdl–137 | 16–22 | 19[c] |

A: Siddiquee et al. (2009); B: Ahmed et al. (2013); C: Hasan et al. (2013b)
[a]IAEA (1989)[59]; [b]GESAMP (1982)[60]; [c]Salomons & Froster (1984)[61]; bdl: below detection limit

In general, these data indicate that the coastal environment of Sitakunda, Chittagong receives a number of different pollutants, potentially from differing sources, one of which, ship recycling, is likely to be making a contribution. In particular, pollutants such as heavy metals are found in sediment to levels higher than in ambient water.

[111]Siddiquee NA, Parween S, Quddus MMA, Barua P, 2009. Heavy metal pollution in sediments at shipbreaking area of Bangladesh. Asian Journal of Water, Environment and Pollution 6: 7-12

**Table 4.9 Average seafood consumption per country (FAO 1998) and calculated tolerable average residue level of TBT in seafood products** (source: Belfroid et al. 2000[112]).

| Countries | Per capita supply | | Tolerable average residue level (TARL)/day in ng/g seafood product for an average person of 60 kg |
|---|---|---|---|
| | in kg/year | in gram/day | |
| Australia | 19.2 | 52.6 | 285 |
| Bangladesh | 9.4 | 25.8 | 582 |
| Canada | 22.7 | 62.2 | 241 |
| France | 27.9 | 76.4 | 196 |
| Germany | 15.6 | 42.7 | 351 |
| Hong Kong | 59.6 | 163.3 | 92 |
| India | 3.8 | 10.4 | 1441 |
| Indonesia | 15.2 | 41.6 | 360 |
| Italy | 23.1 | 63.3 | 237 |
| Japan | 71.0 | 194.5 | 77 |
| Korea Republic | 50.3 | 137.8 | 109 |
| Malaysia | 53.5 | 146.6 | 102 |
| Netherlands | 14.6 | 40.0 | 375 |
| Papua N Guinea | 26.2 | 71.8 | 209 |
| Poland | 16.5 | 45.2 | 332 |
| Portugal | 58.7 | 160.8 | 93 |
| Sweden | 30.8 | 84.4 | 178 |
| Thailand | 25.9 | 71.0 | 211 |
| UK | 20.1 | 55.1 | 272 |
| USA | 21.6 | 59.2 | 253 |
| Vietnam | 12.6 | 34.5 | 435 |

### *4.2.5 Surface and ground water quality*

There are no data that correlate groundwater pollution with ship recycling activity or demonstrate that ship recycling is a source of groundwater pollution. However the contamination of groundwater is of great concern in the area. One study (Ahmed et al. 2010[13]) suggests that the groundwater of Chittagong region contains arsenic (max 0.5 mg/l) at elevated levels exceeding the standard limit set by Bangladesh Standards and Testing Institution (0.05 mg/l) and World Health Organization (10 µg/l) for drinking water. Thus, about 83% of tube-wells of Sitakunda Upazila contained arsenic above the permissible limit. Concentrations of other common groundwater quality parameters are reported to be within the permissible limits, except Fe and Mn.

Physico-chemical and microbiological parameters of the surface water of Kaptailake and other rivers of Chittagong region are also within the permissible limits of WHO guidelines. But, this scenario is different for the Karnaphuli River

[112]Belfroid AC, Purperhart M, Ariese F, 2000. Organotin levels in seafood. Marine Pollution Bulletin, 40 (3): 226-232.

that contains higher levels of BOD, COD, and nitrogenous and phosphorus compound than that of WHO guideline (Rahman et al. 2003[113]; Ahmed et al. 2010)[13]. However, water quality is greatly influenced by the monsoon season.

The presence of heavy metals in the groundwater of ship recycling area of Sitakund is largely unexplored. A recent study suggests that groundwater is highly polluted by Fe, Pb and Hg, moderately by Mn and Al, and slightly by As when compared with WHO and Bangladesh domestic standards for water quality (Hasan et al. 2013a[96]). The authors mentioned that 86% groundwater in the ship scrapping area of Sitakunda coast is affected by seawater mixing, and suggested further investigation for better understanding of the mechanism of groundwater pollution by heavy metals.

#### 4.2.6 *Air Quality and noise level*

There is limited study or report on air quality indicators such as suspended particulate matter (SPM), sulphur oxide (SOx), nitrogen oxide (NOx), including metals and sound level in the area within and around Sitakunda. However, it is likely that the ambient air of ship breaking yards may be affected by heavy metals due to dismantling ships and torch cutting of scrap metal. This needs to be determined. General air pollution from other sources has not been quantified for example by vehicular traffic, combustion sources and other local industry.

In a recent study, higher levels of polycyclic aromatic hydrocarbons (PAHs) and short-chain chlorinated paraffins (SCCPs) were detected in the air of Chittagong city, but dichlorodiphenyltrichloroethanes (DDTs), hexachlorobenzene (HCB), and polychlorinated biphenyls (PCBs) were several orders of magnitude lower in comparison to other studies performed in India and China. In particular, PCBs, PAHs and HCB were highest at sites near the ship recycling activities, whereas DDTs and SCCPs were higher in the urban areas (Nøst et al. 2015[28]). This study has some methodological limitations and therefore it is necessary to verify whether this result is reproducible or appraise the same with other comparable methods.

Suspended particulate matter (SPM), sulphur oxide (SOx) and nitrogen oxide (NOx) are considered to be the main issue pertaining to air pollution problems, but their levels (SPM: 138–163 μg/$m^3$; SOx: 4.1–7.6 μg/$m^3$; NOx: 7.3–14.4 μg/$m^3$) in the air of ship recycling area are inside the permissible limits (SPM: 500 μg/$m^3$; NOx: 100 μg/$m^3$) of Bangladesh Environmental Conservation Rules (ECR, 1997) applicable to industrial and sites with mixed type of activities. The ambient sound levels (62–72 dBa) in the ship recycling yards are also found within the standard range (70–75 dBa; ECR, 1997), Table 4.10.

[113]Rahman IMM, Majid MA, Nazimuddin M, Huda ASMS,2003. Status of arsenic in groundwater of some selected areas of Chittagong district. The Chittagong University Journal of Science 27: 7-12.

**Table 4.10: Ambient air quality data of ship recycling yards, Sitakunda**

| Parameter | Data source (DoE) | Standard level (ECR, 1997) |
|---|---|---|
| SPM (µg/m$^3$) | 138–163 | 500 |
| SOx (µg/m$^3$) | 4.1–7.6 | – |
| NOx (µg/m$^3$) | 7.3–14.4 | 100 |
| Sound level (dBa) | 62–72 | 70–75 |

Suspended particulate matter (SPM); Sulphur oxide (SOx); Nitrogen oxide (NOx)
Standard level for Sulfur dioxide ($SO_2$) is 120 µg/m$^3$ (ECR 1997)

### *4.2.7 Weather and climate*

The area is within a tropical climatic zone and is greatly influenced by the seasonal monsoon wind. For the 1980-2010 period, mean annual temperature ranged from 24.6–27.0 °C (Figure 4.2), but monthly low/high temperature varies from 15–32 °C (Figure 4.3). The mean annual rainfall was 57–414 mm (Figure 4.4) with occurrence of heavy showers between June and September (Figure 4.5). The mean annual relative humidity is maximum in warmer months but varies from 60–90%, and the mean annual (1991-2001) wind speed reported to be 1.8 knots or 2 mph[114] [115].

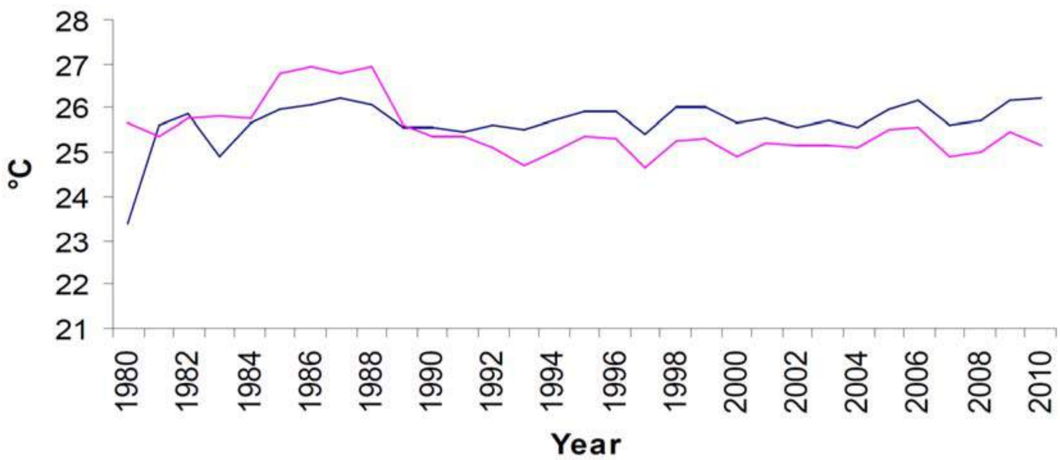


**Figure 4.2. Average annual temperature (°C) changes in the Sitakunda (—) and in the coast of Bangladesh (—); source: Miah et al. (2015)[116].**

[114]Khan YSA, Hossain MS, Chowdhury MAT,2003. Resource inventory and land use mapping for integrated coastal environment management: remote sensing, GIS and RRA approach in greater Chittagong coast. Ministry of science and information & communication technology, Government of the People's Republic of Bangladesh, 68 pp.

[115]Dutta S, Hossain MK, Hossain MA, Chowdhury P, 2015.Exotic Plants and their Usage by Local Communities in the Sitakunda Botanical Garden and Eco-Park, Chittagong, Bangladesh. Forest Research 4: 136. doi:10.4172/2168-9776.1000136.

[116]Miah MNU, Shamsuzzaman MM, Harun-Al-Rashid A, Barman PP, 2015. Present status of coastal fisheries in Sitakunda coast with special reference on climate change and fish catch. Journal of Aquaculture Research & Development 6: 362. doi:10.4172/2155-9546.1000362.

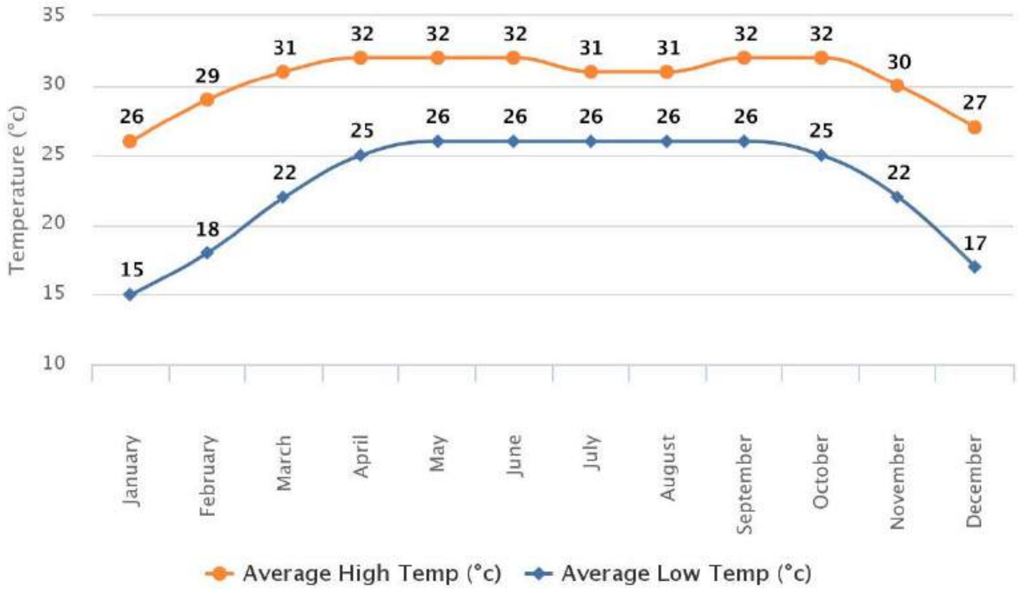


**Figure 4.3. Average high/low temperature (°C) for Sitakunda, Bangladesh. The data taken from year 2000 to 2012 (source: World Weather Online).**

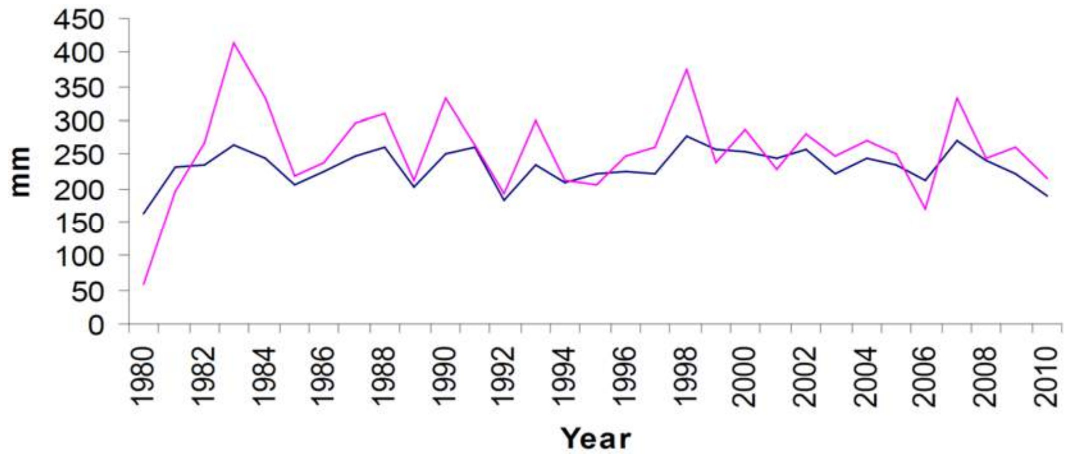


**Figure 4.4. Average annual rainfall (mm) in the Sitakunda (—) and in the coast of Bangladesh (—); source: Miah et al. (2015)[116].**

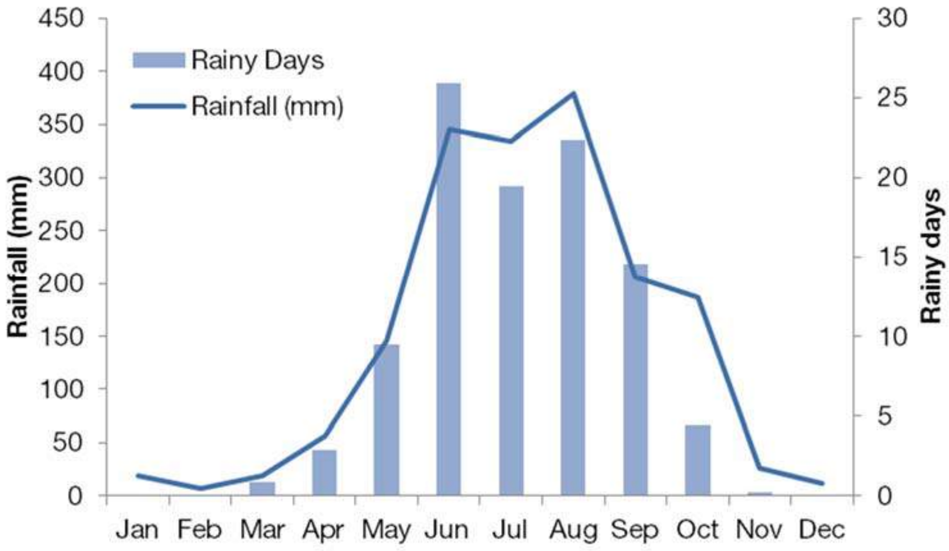


**Figure 4.5. Monthly rainfall patterns at Sitakunda (WMO Weather Station# 41965) based on 4,947 SYNOPs (3.4 reports per day) sent between 01.01.2012 and 31.12.2015. Total annual rainfall averaged over this 4-year period = 1505 mm.**

### *4.2.8 Tropical cyclone and tidal surge*

Occasional thunderstorms, cyclones and storm surges (typically between 3 and 6 metres) occur particularly during the monsoon season. From 1960 to 2009, many cyclones hit Bangladesh. Among them a very powerful and destructive tropical cyclone hit the Cox's Bazar-Teknaf area (wind speed 278 km/hr) at night during 1994. The strongest cyclone hit the Sitakunda coastal area (wind speed 232 km/hr.) at late night in 1997. In 1998, another cyclone hit the Chittagong coast near Sitakunda (wind speed 225 km/hr) at night. Impacts of cyclone and tidal surge alter the function, diversity and productivity of ecosystem and livelihoods. Coastal resources and infrastructures including embankment, mangroves, industry, house, drinking water source, and sanitation facilities maybe severely damaged during cyclonic events. Consequently, food crisis, disease outbreak and environmental contamination forced the people to displace as climate change victims (Figure 4.6).

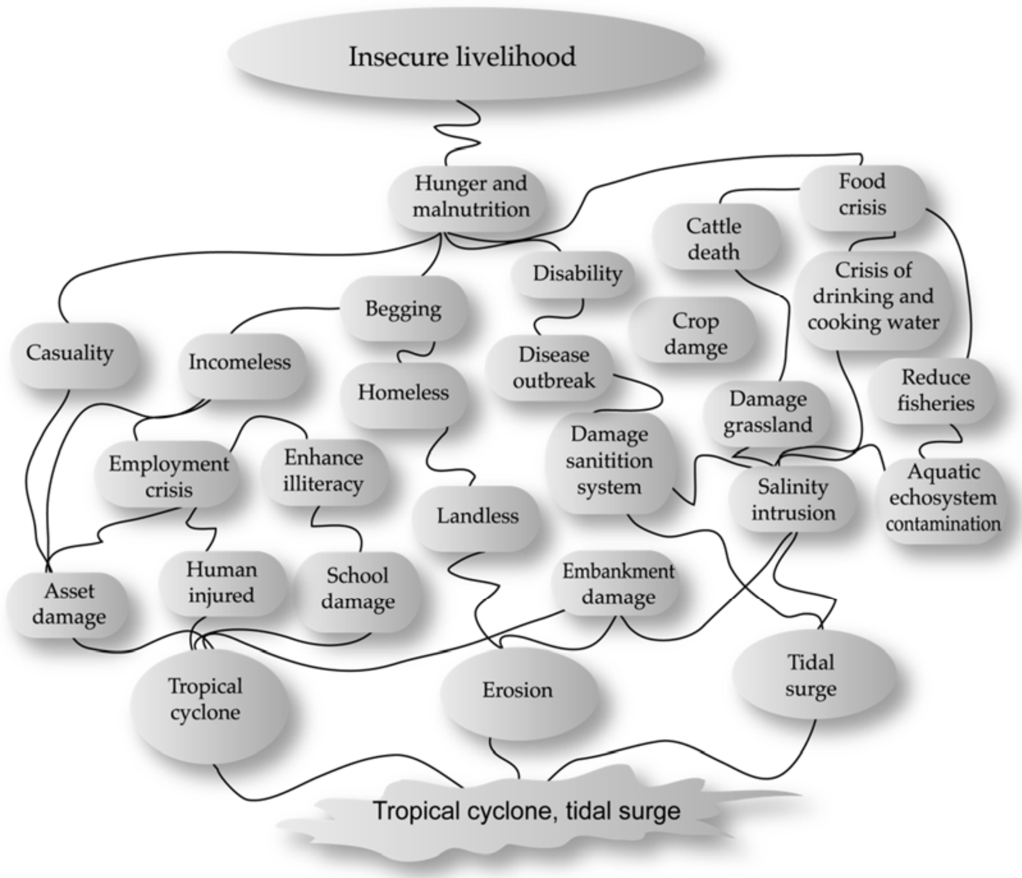


**Figure 4.6.Impacts of tropical cyclone and tidal surge in the coastal environment of Bangladesh (source: Hossain 2009[117])**

### 4.2.9 *Seismicity*

The Sitakunda-Teknaf fault is considered to be one of the two most active seismic faults in Bangladesh. An earthquake in April 1762 led to permanent submergence of 155.4 km$^2$ land near Chittagong and death of 500 people in Dhaka, including emergence of two volcanoes in the Sitakunda hills. Moreover, during a seismic tremor in November 2007, fire broke out at the Bakharabad Gas Systems Limited in the Faujderhat area of the upazila when a pipeline was fractured. In general, Chittagong lies within 200-300kmof a seismically active zone in the neighbouring state of Myanmar, and the earthquakes originating in that tectonically active region are also felt frequently (Figure 4.7).

[117]Hossain MS, 2012.Fishermen Resilience Modeling of Hatiya Island, Bangladesh. University of Chittagong, 32 pp. ISBN 978-984-33-4138-9.

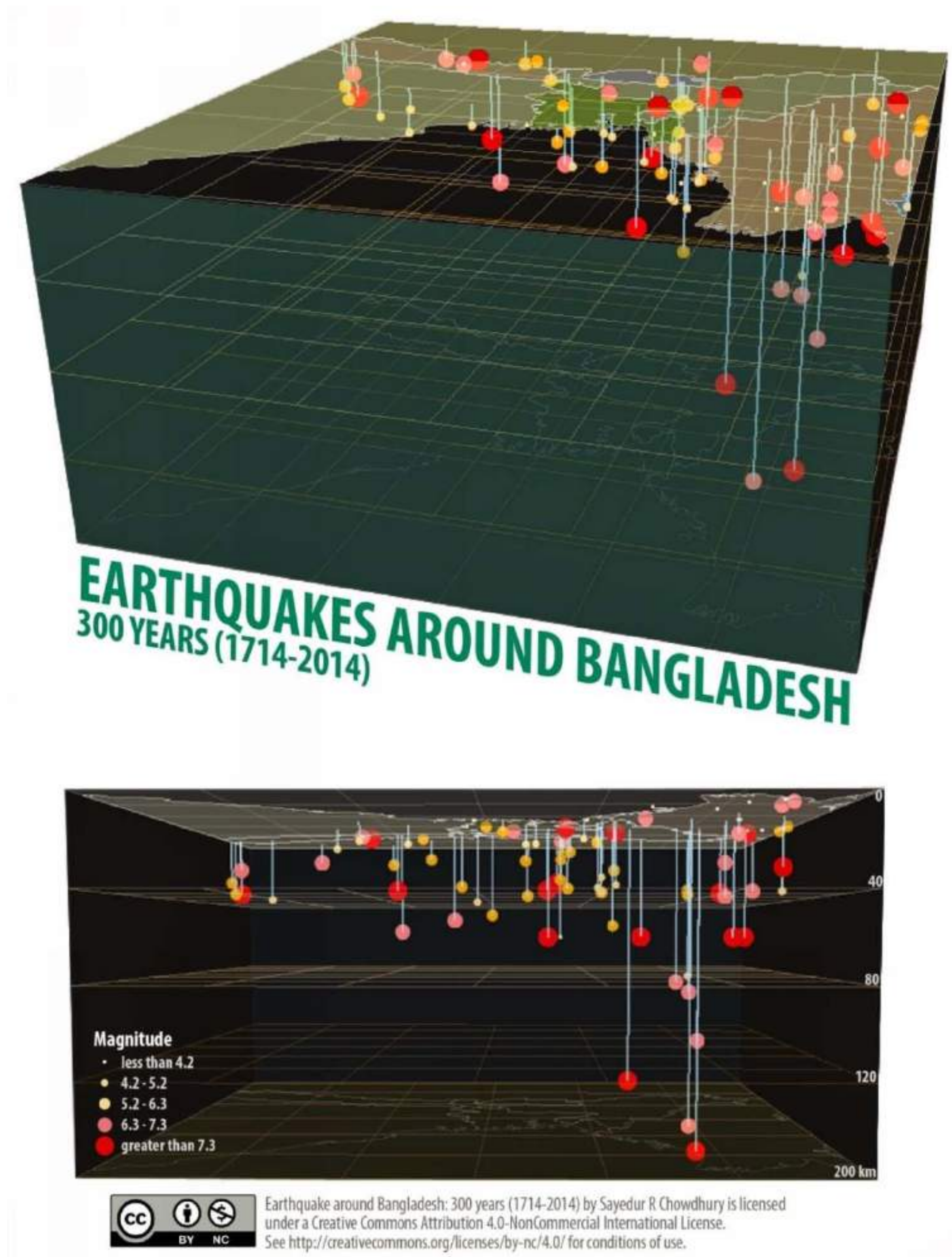


**Figure4.7 Earthquake around Bangladesh (source: mapsnmaps.blogspot.com2014)**

## 4.3 Biological environment

### *4.3.1 Flora*

There are 55 shrubs and 62 herbs in the natural ecosystem of Sitakunda Botanical Garden and Eco-park, which is the first Eco-park in Bangladesh established in 2000. While 203 plant species belonging to 154 genera and 54 families were recorded from the entire Sitakunda Reserve Forest (see Dutta et al. 2015[115]). The forests of the region are known to be evergreen type. The topmost level of forest consists of Garjan (*Dipterocarpusalatus*), Telsur (*Hopeaodorata*), Chapalish (*Artocarpuschaplasha*), Chundul (*Tetramelesnudiflora*) and Koroi or the Moluccan albizia (*Falcatariamoluccana*). The lower level consists of species of Jarul (*Lagerstroemia speciosa*), Toon (*Toonaciliata*), Jam (*Syzygiumcumini*), Jalpai (*Elaeocarpusrobustus*) and Glochidion. Lianas, epiphytes (mostly of orchids, asclepiads, ferns and leafy mosses) and herbaceous undergrowths are abundant. Savannah formations are found in the open, along the banks of rivers and swamps with common tall grasses like Kans (*Saccharumspontaneum*), Shon (*Imperatacylindrica* and *I. arundincca*) and Bena (*Vetiveriazizanoides*). Several species of Bamboo are cultivated including *Bambusabalcooa* (which is also common in Assam), *B. vulgaris*, *B. longispiculata*, *B. tulda* and *B. nutans* (source: Wikipedia).

Both mangrove and non-mangrove species are seen on the green belt along the coast. Mangrove species planted on the newly accreted char land are Keora (*Sonueratiaapctala*), Saclabaen (*Avicenniaalba*), Kala baen (*Avicennia officinalis*), Gewa (*Excoecariaagallocha*), Kankra (*Bruguiragymnorrliiza*), Goran (*Ceriopsdecaudra*), etc. About 90% of the total mangrove plantations are composed of keora. The mesophytic species planted on the raised foreshore and embankments are Babul (*Acacia nilotica*), Akashmoni (*A. auriculifonnis*), Jhau (*Casuarina equisetifolia*), Khoiyababla (*Pithocellubiumdulce*), Rain tree (*Samaneasaman*), Sadakoroi (*Albiziaprocera*), Arjun (*Terminalia arujuna*), Tentul (*Tamarindusindica*), Shon boloi (*Thespcsiapopulnea*), etc (Khan et al. 2003[114]).

Quantitative studies to establish the rate or magnitude of change due to the expansion of ship recycling yards have been recognized (Khan et al. 2003[114], Abdullah et al. 2013[19]) that further needs time series analysis of high resolution satellite imagery and ground truthing.

#### *4.3.2 Fauna*

The coastal area all over Bangladesh is rich in fisheries resources from the prehistoric time. There are around 475 fish fauna including 25 species of shrimps, in the marine water of Bangladesh, according to the fisheries directorate[118]. However, the estuarine set bag net (ESBN) catch composition of the Sitakunda coast only recorded 28 species, of which 20 species of finfish, 2 species of crab and 6 species of shrimp, whereas there are 62 species for the Fouzderhat coast (Miah et al. 2015[116]). According to local fishermen of greater Chittagong coast (Khan et al. 2003[114]), a number of fish species have become endangered in the area such as Bhoal (*Raiamas bola*), Lakhua (*Eleutheronematetradactylum*), Chapila (*Gudusiachapra*), Datina (*Acanthopagrus latus*), Rupchanda (*Pampus argenteus*), Pangash (*Pangasiuspangasius*), Chhuri (*Trichiuruslepturus*), IlshaChandana (*Tenualosatoli)*, Hilsha (*Tenualosailisha*), Faishya (*Anchoviellacommersonii*), Maittya (*Scomberomoruscommerson*), Gnhora (*Labeogonius*), Kata (*Nemapteryxnenga*), Chewa (*Taenioidescirratus*),

[118] Hussain MM,1971.The commercial fishes of the Bay of Bengal. Survey for Development of Fisheries in East Pakistan, 60p.

Sundaribele (*Glossogobiusgiuris*), Bata (*Liza parsia*), Koral (*Etroplussuratensis*) and Kawoon (*Anabas testudineus*), as well as tiger shrimp (*Penaeus monodon*). In the hill areas deer, snake and jackal are common.

## 4.4 Socio-economic condition

### *4.4.1 Population*

Sitakunda has a population of 387,832 distributed to 77,279 units of households (average household size 4.9), including 202,137 male and 185,695 female, or a gender ratio of 109:100 (M/F). Population density is 801/km$^2$ (BBS 2013)[119].

### *4.4.2 Industries and commerce*

The main sources of income are agriculture 24.12%, non-agricultural labourer 4.27%, industry 2.82%, commerce 15.43%, transport and communication 4.32%, service 28.76%, construction 1.56%, religious service 0.29%, rent and remittance 6.10% and others 12.33%. Noted manufacturers include: steel and re-rolling mills, corrugated iron factories, ship recycling, inland container depots, cement factories, glass industries, automobile factory, pharmaceutical industry, textile industries, jute and carpet industries, and oxygen factory. Cottage industries include goldsmith, blacksmith, potteries, wood work and bamboo work (source: Banglapedia; Wikipedia). The ship recycling industry in Sitakunda contributes about 50% of Bangladesh's steel production, and reportedly provides employment for some 22,000–50,000 people directly and some 100,000–200,000 indirectly (World Bank 2010[27]). A sizeable population is also directly or indirectly dependent on the coastal capture fishery. Fishing plays an important role in the economy and livelihood of rural people.

[119] BBS, 2013. District Statistics 2011, Chittagong.http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/District%20Statistics/Chittagong.pdf, Accessed on May 2016.

## 5. Potential Impacts

### 5.1 General considerations

Ship recycling and recycling is a growing industry in the world because of its economic importance. It is a complex process involved with many health, safety and environmental issues. The Sitakunda coast was considered suitable for establishment of ship recycling yards for geological, topographical and economic advantages such as, long uniform intertidal coastline with tidal differences of 6 meters, favourable weather condition, local market demand for steel and iron, low labour cost, little environmental awareness and moderate implementation of environmental laws[120]. Consequently, over a 25 year period, the longitudinal extent of the shore used for ship recycling yards has expanded from about 3 km in 1989 to nearly 15 km in 2014 (Figure 5.1). Up to 2.2-2.5 million tons of national steel production comes from the ship recycling industry annually. There are some 40 active ship recycling yards and 250-350 re-rolling mills in Bangladesh[27].

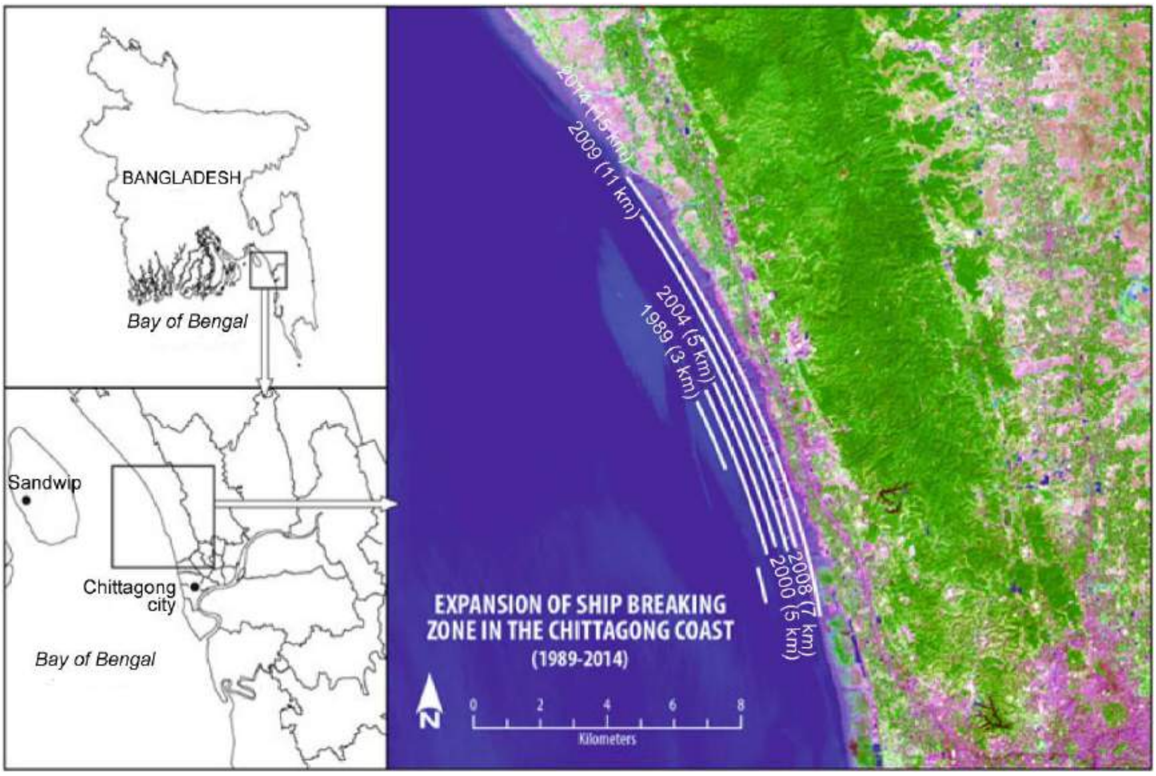


**Figure 5.1. Growth of ship breaking area (1989-2014) in the Chittagong coast[15]**

### 5.2 Scoping of impacts

The ship recycling industry among others may create potential hazards for the coastal and marine environment. The coastal area nearby the ship recycling zone is vulnerable to serious environmental harm from heavy metal pollution that impacts on biodiversity. Section 4.2.4 describes levels of heavy metals in the sediments of ship recycling area in comparison with recommended values of marine sediments, which do not seem to

[120]YPSA, 2005.Workers in ship breaking activities and its impact on the coastal zone of Chittagong, Bangladesh: Towards sustainable management. YPSA, Chittagong, p.79.

indicate excessive or potentially harmful contamination. Heavy metals accumulation in the tissue of aquatic organisms, such as saltmarsh, molluscs, crustaceans and fish, has been reported from coastal and marine waters of Bangladesh[121,122, 123], but no such study is done in the Sitakunda coast. The BOBLME study[124] on pollution monitoring along the river, estuarine and coastal areas of Bangladesh points to impacts from many pollution sources, among which ship breaking is but one. More evidence of causation would need to be sought through studies that identify a correlation between the activity and contamination such as data available showing concentration vs distance from potential sources.

Adverse effects on fish, both in natural and under laboratory conditions, have been reported due to heavy metal toxicity that may include reduced fertility, problematic reproduction, hatching delay, damaged kidney, slower growth and development, organ deformities, abnormal behaviour and even death. Moreover, fish are expected to have damaged gills, gut and sensory systems under elevated levels of toxic metals. Along the food chain, accumulated metals in the tissue of marine organisms (Habashi 1992[125], Peplow 1999[126], Jakimska et al. 2011[127]) can be bioaccumulated and then biomagnified (e.g., grazer → primary consumer → secondary consumer → top predator) to various extents (Figure 5.2). The tolerance limits of some heavy metals are shown in Table 5.1. Fu & Wu (2005) reported bioaccumulation of PCBs (69–220 ng/g) in mullet fish (*Liza macrolepis*) from the Ann-Ping harbour in Taiwan where ship dismantling activity was operated in the 1980s[128].The authors concluded that even though PCB contamination stopped for over a decade, the residual contaminants in soil and sediments still continue, contributing to the body burden of fish residing in the estuary and the harbour. Humans, in turn, are in risk of toxicant exposure through consumption of contaminated seafood that known to cause a wide range of toxic effects, such as carcinogenicity, mutagenicity and teratogenicity.

However, the accumulation and magnification of metals/toxicants by aquatic organisms in the Sitakunda ship recycling area must be studied in order to determine what contribution, if any, is being made by this or other activities.

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121 Hossain MS, Khan YSA, 2001. Trace metals in Penaeid shrimp and Spiny lobster from the Bay of Bengal. Science Asia 27: 165-168.

122 Ahmed K, Mehedi Y, Haque R, Mondol P, 2011. Heavy metal concentrations in some macrobenthic fauna of the Sundarbans mangrove forest, south west coast of Bangladesh.Environmental Monitoring and Assessment 177:505-514.

123 Siddique MAM, Kamal AHM, Aktar M, 2012. Trace metal concentrations in salt marsh sediments from Bakkhali River estuary, Cox's Bazar, Bangladesh. Zoology and Ecology 22: 254-259

124 Hossain, M. Maruf., Kibria, G, Mallick, D, Lau, TC, Wu, R and Nugegoda, D. 2015. Pollution Monitoring in Rivers, Estuaries and Coastal Areas of Bangladesh with Artificial Mussel (AM) Technology- Findings, Ecological significances, Implications & Recommendations. BOBLME (2015) Pollution monitoring in rivers, estuaries and coastal areas of Bangladesh with Artificial Mussel (AM) technology. BOBLME-2015-Ecology-30

125 Habashi F, 1992. Environmental issues in the Metallurgical Industry – Progress and Problems, Environmental Issues and Waste Management in Energy and Mineral Production. Balkama, Rotherdam, pp. 1143-1153.

126 Peplow D, 1999. Environmental Impacts of Mining in Eastern Washington, Center for Water and Watershed Studies Fact Sheet, University of Washington, Seattle.

127 Jakimska A, Konieczka P, Skora K, Namiesnik J, 2011. Bioaccumulation of metals in tissues of marine animals, Part I: the role and impact of heavy metals on organisms. Pol. J. Environ. Stud., 20(5): 1117-1125.

128 Fu CT, Wu SC, 2005. Bioaccumulation of polychlorinated biphenyls in mullet fish in a former ship dismantling harbour, a contaminated estuary, and nearby coastal fish farms. Marine Pollution Bulletin 51: 932-939.

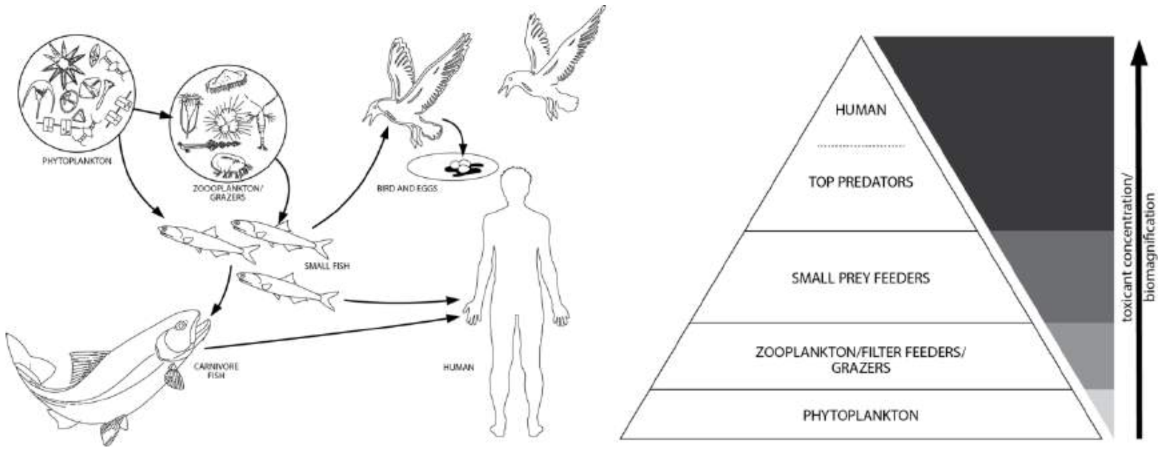


**Figure 5.2.General scope of impacts of pollutants on food chain up to top predators** (source: Sharifuzzaman et al. 2016[15]).

**Table 5.1. United State Environmental Protection Agency (USEPA) and WHO maximum contamination levels for heavy metal concentration in air, soil and water (source: Duruibe et al. 2007[129]).**

| Heavy metal | Max conc. in air ($mg/m^3$ ) | Max. conc. in sludge (soil) (ppm) | Max. conc. in drinking water (mg/l)[a] | Max conc. in $H_2O$ supporting aquatic life (ppm) |
|---|---|---|---|---|
| Cd | 0.1-0.2 | 85 | 0.005 | 0.008 |
| Pb | --- | 420 | 0.01 | 0.0058 |
| Zn | 1.5 | 7500 | 5.00 | 0.0766 |
| Hg | --- | <1 | 0.001 | 0.05 |
| Ca | 5 | Tolerable | 50 | Tolerable >50 |
| Ag | 0.01 | --- | 0.0 | 0.1 |
| As | --- | --- | 0.01 | --- |

[a] maximum acceptable concentration by WHO

[129] Duruibe JO, Ogwuegbu MOC, Egwurugwu JN, 2007. Heavy metal pollution and human biotoxic effects. International Journal of Physical Sciences Vol. 2 (5), pp. 112-118.

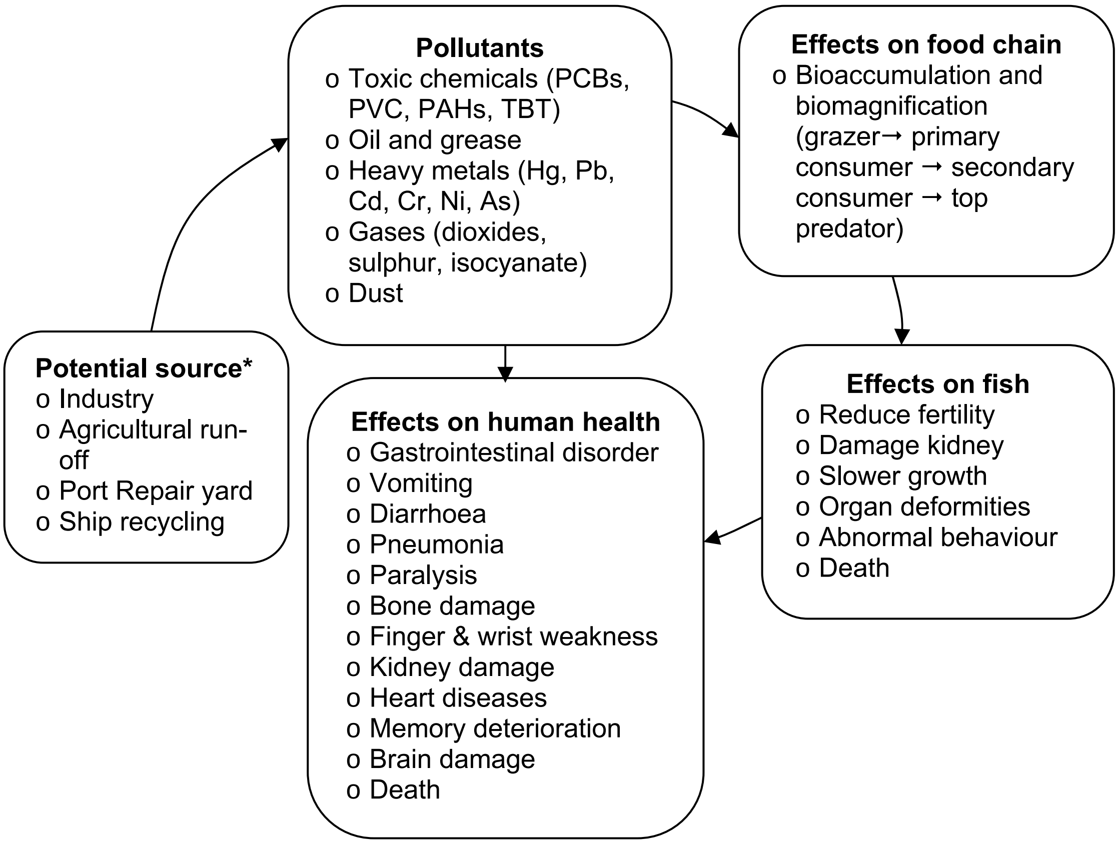


**Figure 5.3. Scoping of potential impacts (source: Local Environmental Consultants 2016[18])**

## 6. Evaluation of Impacts

**NOTE:**

The text in this section is illustrative of what might be incorporated into an Environmental Impact Assessment and is included here to show the type of measures that would be considered. The current state of knowledge of the actual contribution from ship recycling at Sitakunda to environmental impact is imperfect and further, more detailed, study would be needed in order to clarify more precisely appropriate and necessary interventions.

### 6.1 Evaluation of impacts

Monitoring and evaluation are processes which assist in answering the question, “Is the plan working?” and, if it is not working, what future actions are needed to make it work. Monitoring is a process where repetitive measurements in time and space are recorded to indicate natural variability and changes in environmental, social and economic parameters. Impact evaluation assesses the changes that can be attributed to a particular intervention. It helps to answer key questions for evidence-based policy making: what works, what doesn’t, where, why and for how much? Ship recycling in its current state represents a potentially serious threat to the surrounding environment. But its unique contribution is difficult to determine. Environmental concerns are first and foremost related to the harmful substances involved and the lack of containment allowing toxins to enter the environment and the food chain. The nature of the recycling sites (intertidal zone) allows tidal wash-out and mixing with pollutants from other sources hence, immediate effects may be avoided on the shore. However, habitat degradation, decline in biodiversity, presence of pollution indicator species have been claimed in some of these areas.

To ensure the effective implementation of the proposed mitigation measures, the broad objectives of monitoring plan are:

- To evaluate the performance of proposed mitigation measures
- To evaluate the adequacy of environmental impact assessment
- To suggest improvements in environmental management plan
- To enhance environmental quality
- To implement and manage the defined mitigation measures
- To undertake compliance monitoring of the proposed project operation and evaluation of mitigation measure.

### 6.2 General considerations

In the context of an environmental management plan with regard to establishment of ship recycling facilities, an environmental management plan (EMP) is considered to be an integral part of design, planning and operational phases during implementation of such project. In this particular case, activities concerning (i) location selection, (ii) construction, (iii) operation stages as well as resultant impacts arising out of these activities during implementation, will be taken into account separately with a view to protecting the environmental health and resources as identified referred to baseline environment and identification of impacts.

The potential impacts will focus on suitable mitigation measures along with environmental management system on important environmental issues/parameters/, to protect the surrounding environment from significant impacts. The environmental attributes to be monitored to ensure proper implementation and effectiveness of various mitigation measures adopted during operation of the proposed project are described here under.

## 6.3 Adverse impacts and mitigation

### *6.3.1 Impact due to project location*

The ship recycling site is located in the heavy industrial belt of Faujderhat-Kumira-Sitakunda at Chittagong along the coast of the Bay of Bengal. The area hosts a lot of small and large industries, including steel and re-rolling mills, corrugated iron factories, ship recycling, inland container depots, cement factories, glass industries, automobile factory, pharmaceutical industry, textile industries, jute and carpet industries, oxygen factory and many other important business installations. The site is easily accessible by water and road. The Dhaka-Chittagong highway (called as the Asian highway) and the railway pass beside the area. Moreover, local feeder roads are suitable for running vehicles throughout the year that also connected with the Asian highway. The area supports streams, Sandwip Channel, accreted mud flats, salt marsh, mangrove ecosystem, and plain land. Moreover, the vicinity of the recycling area includes villages, water bodies, cropland, community centres, schools and colleges. So, impacts on the surrounding environment and land/water uses to some extent are anticipated.

### *6.3.2 Impacts during construction*

The ship recycling yards are principally located in the coastal lands (i.e., sub-tidal, intertidal, littoral and supra-littoral zones). Environmental effects of the construction phase are expected to be temporary. The principal activities in this phase consist of the engineering survey, procurement of materials and their transport to project site, besides site development and construction, commissioning of proposed physical works. Infrastructure building, internal service facilities development, installation of machinery equipment, and service connections which comprises of the civil works including soil cutting, filling and pilling for foundation of recycling facilities premises, internal drainage system, internal road network, storage and labour shed, water supply and sanitation, administration building, and so on.

Construction impacts are considered to be minimal as construction materials and equipment will be required to be delivered to site by road. Construction will have some potential but minor impact upon air quality, primarily related to dust and grit with lesser problems arising from exhaust emissions of vehicle pollution. In addition, increased traffic movement in and around the location may cause some disturbance but it is limited to the construction site only. Minor impacts due to generation of fugitive dust from earth-workings and civil construction works, air pollution due to exhaust gases from vehicle movement and traffic congestion can be managed by controlled watering on the land and through controlled vehicle movement during the peak hours of local traffics. Air quality deterioration may be for a short period and minor impact is anticipated. Noise is not considered to be a problem and the noise/vibration activities occur during the daytime hours only. Minor impact is anticipated. For new yard construction, loss of vegetation and habitats, effect on littoral zone as well as spillages, noise and dust particles are expected to impact the natural environment.

#### *6.3.3 Impact during operation stage*

The major activities of this stage of ship recycling activities involve operation and maintenance to ensure smooth running of the recycling facilities and associated equipment. The following section has been synthesized based on US OSHA (2010)[130].

##### *6.3.3.1 Impacts of asbestos and asbestos containing material (ACM)*

Asbestos and ACM is found in different parts and materials (such as board, pipe lagging, insulation and fire retardant materials) on ships. When ACM is deteriorated, crushed or disturbed, asbestos fibres break up into very fine fibres and are released to the environment by either dispersing in the air, floating on water or accumulating on the ground.

##### *6.3.3.2 Impacts of Poly Chlorinated Biphenyls (PCBs)*

PCBs are a group of synthetic organic chemicals that are found in electrical insulations/cables, electrical equipment such as capacitors and transformers, rubber and plastics, lubricating oils, engine oil, hydraulic fluids, gaskets, sealing materials, painted surfaces, etc. The empirical formula is $(C_{12}H_{10X})Cl_X$, and PCB containing wastes (>50 ppm) are classified as “Hazardous” wastes.

##### *6.3.3.3 Impacts of E-Wastes*

Used electrical and electronic devices, i.e. E-wastes (such as cables and wires, TV, refrigerator, telecommunication, lighting and heating equipment, etc.) are likely to contain PCBs, heavy metals (Lead, Beryllium, Copper, Cadmium, Mercury, Antimony, and Hexavalent Chromium), PVCs and complex organic compounds such as Octabromodiphenyl ether (OBDE), Tetrabromo-bisphenol A (TBBPA). Many of these are toxic and once they enter the food chain can have long term effects (as referred in Figure 5.2).

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[130] OSHA (2010) Safe Work Practices for Shipbreaking. OSHA 3375-03, Occupational Safety and Health Administration U.S. Department of Labor, 28 pp.

*6.3.3.4 Impacts of paint chips*

About 95% material in ship is steel and coated with 10-100 tons of paint, depending on the size and function of ships (5,000-40,000 tons), which cause environmental pollution when the ship is broken (Hossain and Islam 2006[131]). Paint chips are likely to contain heavy metals such as lead, mercury, chromium, arsenic, copper, zinc, aluminium, and toxic additives to inhibit marine growth and PCBs (IL&FS Ecosmart Limited 2010[132]). In the marine environment, most heavy metals are present in the sediments and only a small fraction is present as dissolved salts in the water. The metals are very slowly released from the sediments to the water (Khan et al. 1998[133]). Heavy metals undergo bio-accumulation and bio-magnification as they are cycled through the food chain. The ecological significance of pollutant metals relates to their uptake and accumulation by organisms including molluscs (Hossain et al. 2003[134]). The metal contents of bivalves have been widely used in biomonitoring programs of metal pollution in the marine environment; therefore, there is a strong interest in the problem of the interaction of ecological and physiological factors affecting the accumulation of metals by molluscs (Phillips 1980[135], Cossa 1989[136]). Most research in this area has been performed on species of the genus *Mytilus* (Shulkin and Kavan 1995[137]).

Identification of potential impacts during project construction and operation has been done using the checklist method and presented in Table 6.1 (developed from expert judgement, literature reviews and stakeholder consultation and may be subject to review). In this checklist, major actions/activities which may occur at various stages of the proposed facility are listed and the degrees of Significant Environmental Impacts (SEIs) are shown. The term none, minor, medium and major are used in this checklist to classify the magnitudes of SEIs. Summarizing the findings and observations from the checklist, it can be observed that the major activities that have associated major/potential impacts whether adverse or beneficial on various environmental components are erosion patterns, ecological encroachment, pollutants (air, water and ground), noise and vibration hazard, accidental risk, occupational health and safety, and socio-economic condition.

[131] Hossain MMM, Islam MM, 2006. Ship breaking activities and its impact on the coastal zone of Chittagong, Bangladesh: towards sustainable management. YPSA, Chittagong, Bangladesh, 65 pp.

[132] IL&FS Ecosmart Limited, 2010. Technical EIA Guideline Manual for ship breaking yards. Prepared for the Ministry of Environment and Forest, Government of India, Hyderabad, 238 pp.

[133] Khan YSA, Hossain MS, Hossain SMGA, Halimuzzaman AHM, 1998. An Environmental Assessment of trace metals in the Ganges-Brahmaputra-Meghna Estuary. *Journal of Remote Sensing and Environment*, Vol. 2: 103-117.

[134] Hossain MS, Nath SK, Khan YSA, 2003. Trace metals in Bivalve Molluscs, *Pernaviridis* and *Crassostreamadrasensis*, from the north-eastern coast of the Bay of Bengal. Chiang Mai Journal of Science, Vol. 30(2): 103-111.

[135] Phillips DJH, 1980. Quantitative aquatic biological indicators: Their use to monitor trace metal and organochlorine pollution. Applied Science Publisher, London.

[136] Cossa D, 1989. A review of the use of *Mytilus* spp. as quantitative indicators of cadmium and mercury contamination in coastal waters. Ocean Acta, 12: 417-432.

[137] Shulkin VM, Kavan VIA, 1995. The use of marine bivalves in heavy metal monitoring near Vladivostok, Russia. Marine Pollution Bulletin, 31(4-12): 330-333.

**Table 6.1.ExampleChecklist for environmental quality parameters- developed based on expert judgement, literature reviews and stakeholder consultation (source: Local Environmental Consultants 2016[18])**

| Project Phase | Action affecting environmental resources and values | SEIs without mitigation measures | | | | Type | | Comments |
|---|---|---|---|---|---|---|---|---|
| | | None | Minor | Medium | Major | Adverse | Beneficial | |
| Construction phase | Loss of homestead land | | + | | | + | | Generations-old homestead near the project area, minor impact is anticipated. |
| | Loss of agricultural land | | | | | | | Agriculture land near the project area, minor impact is anticipated. |
| | Erosion patterns | | | + | | + | | Erosion is involved, medium impact is anticipated. |
| | Encroachment into precious ecological features | | | | + | + | | Encroachment of mangrove forest and salt marsh ecosystem, major impact is anticipated. |
| | Fugitive dust generation and air pollution | | + | | | + | | Dust and air pollution somehow be created during earthwork of temporary access road, vehicular pollution through exhaust emission and civil works, boring of pillars, concrete making, etc., minor impact. |
| | Sanitation/disease hazard | | + | | | + | | Some possibilities are there due to concentration of labour force through generation of sewage discharge. Proper sanitation practice needs to follow, minor impact. |
| | Noise/vibration hazard | | + | | | + | | Piling and civil construction may create noise and vibration, minor impact. |
| | Traffic congestion | | + | | | + | | Some traffic congestion would occur due to heavy vehicles as well as construction equipment and materials handling, minor impact. |
| | Worker accident | | + | | | + | | May occur in all stages of construction works, which can be eliminated by careful implementation of good construction practice and by good environmental management plan, minor impact. |
| | Employment | | | + | | | + | Some employment opportunity will be generated, beneficial impact anticipated. |
| Operation phase | Impacts of asbestos and asbestos containing material (ACM) | | | | + | + | | Asbestos fibers can disperse in the air, water or on the ground; inhalation occurs to workers, their family members, local people and other animals; major impact. |
| | Impacts of Poly Chlorinated Biphenyls (PCBs) | | | | + | + | | PCBs contaminate water and accumulate organisms via food chain; pass the placental barrier to affect the foetus; depress immune system; major impact. |
| | Impacts of E-Wastes | | | | + | + | | Enter food chain and can have long term toxic and teratogenic effects, major impact. |
| | Impacts of paint chips | | | | + | + | | Undergo bio-accumulation and bio-magnification through food chain; adverse effects on higher tropic organisms, major impact. |
| | Impact of CFCs, ammonia, $CO_2$ cylinders, chemical fumes | | | | + | + | | Excess exposure may be fatal, ozone depleting substances, major impact. |
| | Impact of oil, lubricants, ballast water | | | | + | + | | Water and sediment pollution, enter food chain, toxic effects and mortality of aquatic organisms, invasive organisms, major impact. |
| | Non-hazardous solid waste, sludge | | + | | | + | | Higher garbage volume increase disposal costs, needs storage space, may enhance fire accident, minor impact. |
| | Impact of radioactive materials | | | | + | + | | Radioactive materials may disperse in the surrounding environment with long term effects on aquatic and terrestrial organisms including human being, major impact. |
| | Impact of fire | | | | + | + | | Fires in shipyard and vessel are complicated to outside fire response agency, major impact. |
| | Traffic Congestion | | + | | | + | | Traffic congestion may occur due to frequent transport of scrap materials, minor impact. |
| | Noise hazard | | + | | | + | | Heavy noise generation is expected, minor impact. |
| | Socioeconomic effect | | | + | | | + | Good number of personnel and workers are needed; ship-borne materials support new business opportunities, beneficial impact. |

### 6.3.4 *Impact on air quality*

At the ship recycling yards, LPG (Liquefied Petroleum Gas) is used for gas cutting of ships. Other than $CO_2$, NOx also be generated. Thus, annual NOx generation needs to be estimated at Sitakunda. All the gaseous wastes is generated and hence easily dispersed and diluted, more so because of prevailing wind speeds.

High Speed Diesel (HSD) is also used as fuel in diesel powered material handling equipment and vehicles. This leads to generation of NOx. The NOx in vehicular emissions is also be emitted over a wide area and be easily dispersed and diluted.

Fugitive dust is generated due to handling of rusted steel plates on the beach. Iron dust is hard and heavy. It is not spread beyond the ship recycling yards. The land of the ship recycling area is compacted, which reduces fugitive dust generation.

Ships usually contain ammonia and/or Chloro-Fluoro Carbons (CFCs) in the refrigeration systems. Halons may be present in fire-fighting systems. Ammonia is toxic and even in small quantities causes irritation in the eyes and respiratory tract. Excess exposure may be fatal. CFCs and halons are ozone depleting substances.

*Mitigation measures*

The ship recycling activity is not expected to raise general air pollution levels significantly although local exposure is possible depending on the mode of operation of dismantling equipment etc.

### 6.3.5 *Impacts on water environment*

The ship recycling activities may not have drawn freshwater from the nearby waterbody or ground water, though drinking water abstraction has been seen at some yards. Hence no impacts are anticipated on water resources of the area. Major effluents and their impacts are given in Table 6.2.

**Table 6.2. Impacts of ship-borne effluents on marine environment**

| Effluents | Impacts |
|---|---|
| Ballast water | • Invasive species with effects on the local ecology<br>• Cause water and sediment pollution<br>• Bio-accumulation and bio-magnification in food chain<br>• Lead to mortality of marine organisms |
| Bilge water | • May contain high concentrations (even >15000 mg/l) of oil<br>• If untreated bilge water is discharged into the sea, oil slicks are formed in vast areas<br>• Oil slick hamper air-sea interaction process and photosynthetic activity<br>• Toxic effects on marine organisms, which may be fatal |
| Slops generated during washing of cargo tanks and pipelines of oil tankers | • Cause water and sediment pollution<br>• Contaminate marine organisms |
| Oily water generated due to washing of fuel tanks prior to cutting | • Cause water and sediment pollution<br>• Contaminate marine organisms |
| Sewage from the rest rooms and canteens | • Microbial contamination in water, sediment and marine organisms |

*Mitigation measures*

Ship-borne effluents that may contaminate water and their mitigation options are given in Table 6.3.

**Table 6.3. Mitigation options of ship-borne effluents**

| **Effluent management** | **Mitigation options** |
|---|---|
| Ballast water management | • Ballast water handling logs can be scrutinized prior to grant beaching permission<br>• Beaching permission can be granted after ensuring that ballast water has been completely exchanged in high seas outside Bangladesh waters<br>• Ballast water should not be pumped out into coastal waters<br>• |
| Bilge water management | • Filtered onboard systems prior to grounding<br>• After the ship has been raised to beach, bilge water can be pumped to the shore based storage tanks for oily water treatment facilities |
| Slop water management | • Filtered onboard systems prior to grounding<br>• After the ship has been raised to beach, bilge water can be pumped to the shore based storage tanks for oily water treatment facilities |
| Fuel tank wash water management | • The contents of the fuel tanks are not classified as “hazardous”<br>• The residual unused fuel can be pumped out after the ship has been grounded<br>• After the ship has been raised to beach, wash water can be pumped to the shore based storage tanks for oily water treatment facilities |
| Sewage | • Sanitary sewage generated in toilets will be treated in septic tanks and soak pits |

### *6.3.6 Impact on noise environment*

The existing noise level in the recycling yards, need to measure both for day and night time. The major noise generating activities at the yard are operation of diesel powered material handling machinery, handling of large pieces of metal and trucks carrying away recovered materials. Noise level is likely to increase in the ship recycling yards as the yards become operational.

*Mitigation measures*

(Noise mitigation is covered in section 7.3.5 of this report. other appropriate mitigation measures are covered in other work packages)

*6.3.7 Impact on biological environment*

As already indicated, the ship recycling area is located along the coast of Sitakunda, covering intertidal mud flat, mangrove forest, salt marsh ecosystem and tidal streams that originated from the nearby hilly regions. The fauna found in this area has been described in Section4 of this EIA report under paragraph 4.3. As regards impact on wildlife is concerned, most of the wild life in the project areas and its vicinity are confined to common small species, found on the outskirts of villages in most parts of Sitakunda-Mirsarai area.

The strong light in ship recycling premises during night may cause disturbances in the movement, prey and predation, and other biological behaviour to the fauna in the nearby areas. Moreover, contaminated air, severe sound, and vibration may cause faunal habitat displacement. Similarly, contaminated water may cause migration or death of aquatic organisms including flora, fauna and microbes.

*Mitigation measures*

All the light posts erected along the boundary of the recycling yards need to face inwards and down wards (with reflectors facing the project area and downwards), so that the light does not spread outside the yard boundary. Following the mitigation measures for air and noise (as described above) is necessary to ensure favourable living habitats. Moreover, plantation with suitable indigenous plant species (combination of fruity, woody and medicinal) may prevent the spread of fugitive dust generated due material handling, attenuate noise and vibration, and increases green coverage with improve aesthetics. Proper collection, treatment and disposal of hazardous materials can minimize the contamination of water and soil that support favourable environment.

*6.3.8 Impact on occupational safety & health*

The work place is divided in terms of activities e.g. dismantling, metal cutting, material removal, material sorting, staking, loading, etc. The principal occupational risks in ship recycling yards are described in other Work Packages.

*Mitigation measures*

(Appropriate mitigation measures are covered in other Work Packages)

## 6.4 Beneficial impacts and enhancement

*6.4.1 During construction*

Positive effects during construction include the prospect of temporary employment for local labourers and people and an injection of capital into the local economy. In addition the coastal environment maybe more stable and resilient against natural hazards.

### *6.4.2 During operation phase*

(This topic is relevant for other Work Packages)

# 7. Environmental Management Plan (EMP)

**NOTE:**

The following are generic examples of the content of an appropriate EMP for ship recycling including environmental monitoring to show the context in which environmental monitoring and mitigation measures are placed. Other SENSREC Work Packages will contain more detail.

## 7.1 General Considerations

An Environment Management Plan (EMP) would contain information concerning all mitigation measures for each activity to be undertaken during the construction, operation and the entire life cycle to minimize adverse environmental impacts as a result of the activities of the project. It would also delineate the environmental monitoring plan for compliance of various environmental regulations and the steps to be taken in case of emergencies, such as accidents at the site, including fires.

## 7.2 Mitigation/Benefit enhancement measures

Training in occupational health and environmental management is needed for the yard managers, supervisors, and the work force. Training and guidance is required for the development and implementation of management plans covering the aspects of worker safety and training, protection of human health and the environment, roles and responsibilities of personnel, emergency preparedness and response, monitoring, reporting, and record-keeping systems. A central facility needs to be developed to assist industry and authorities and to train in hazardous materials inventories on ships and hazardous materials management on shore. However, considering the large employment generation capabilities in an industry that may be susceptible to large cost increases from environmental mitigation, financial support may need from government or development partners.

## 7.3 Environmental management during operation phase

### *7.3.1 Overview of impacts and mitigation measures*

A number of procedural matters can be implemented as part of the operation of the central waste management unit (CWMU, or treatment storage and disposal facility, TSDF) and these maybe an integral part of the management plan. These are as follows:

- an operations and maintenance manual for the system and the machinery incorporated into the system should be in an accessible location. This may be an integral part of the overall management plan;
- a capable manager should be assigned the responsibility for waste management with adequate and trained staff to implement the waste management plan;

- all personnel involved with the management and operation of the unit should be trained in all aspects of the facility;
- appropriate protective clothing and equipment should be provided for staff handling wastes;
- signs, notices and checklists should be provided at each waste management unit in appropriate languages and with appropriate international symbols;
- the facility should be maintained in a functional manner so that it operates at the required standard at all times;
- the plant and its operation, including its throughput, should be monitored to ensure that it is maintained and used in a satisfactory manner and the facility is being used in the most efficient manner; and
- a constant review of the facility, its standard of discharges, throughputs and administration should be carried out.

### *7.3.2 Atmospheric emission management*

**Description:**
To reduce the discharge of pollutants to the air during ship recycling.

**EMPs:**

- Develop air quality management proceduress for distribution among the supervisors and labour contractors, particularly the cutter groups.
- Prohibit blowing tubes before beaching.
- Encourage alternative fuels and fuel mixtures.
- Encourage use of lower volatile paints.

| **Targeted activities** |
|---|
| Ship operational air emissions |
| |
| **Potential pollutants:** |
| Nitrogen oxides |
| Sulfur dioxides |
| Isocyanides |
| Particulates |
| Hazardous air pollutants |
| **Target environmental media:** |
| Air |
| |

### *7.3.3 Management of solid wastes*

**Description:**
Prevent discharge of contaminants associated with solid waste handling.

**EMPs:**

- Empty solid waste containers frequently
- Ensure that containers are easily accessible
- Clearly mark containers to minimize disposal of hazardous materials such as paints and solvents
- For garbage skips, wastes should be bagged, skips should be emptied when full
- Develop information packages designed for ship captains, identify soild waste reception facilities and acceptable handling procedures
- Keep accurate records of solid waste storage and disposal activities
- Monitor materials placed in containers/bins; remove batteries, fluorescent light fixtures, and containers with solvents and paints, and other hazardous wastes.

**Targeted activities**

Solid waste collection

Solid waste treatment

Solid waste disposal

**Potential pollutants:**

Oils and grease

Petroleum hydrocarbons

Metals, solvents, paint

**Target environmental media:**

Surface water

Soil

### *7.3.4 Wastewater management*

| **Description:**<br>Prevent discharges of wastewater such as oil or chemicals from ships as well as from storage tanks and machinery used on-site.<br><br>**EMPs:**<br>❑ Ship recycling yards should have sufficient tanks to collect and temporary store wastewater.<br>❑ Keep storage tanks above the highest high water mark.<br>❑ Have spill response materials readily available.<br>❑ Clearly mark spill response materials with easy access conducted.<br>❑ Storage areas should be clearly marked noting materials stored, emergency contacts, and spill cleanup procedures.<br>❑ Wastewater should treat and reuse as per environmental guidelines.<br>❑ There will be no direct discharge of wastewater. | **Targeted activities**<br><br>Wastewater collection<br><br>Wastewater handling<br><br>Wastewater treatment<br><br>**Potential pollutants:**<br><br>Oils and grease<br><br>Petroleum hydrocarbons<br><br>Metals, solvents, paint<br><br>**Target environmental media:**<br><br>Surface water<br><br>Soil |
|---|---|

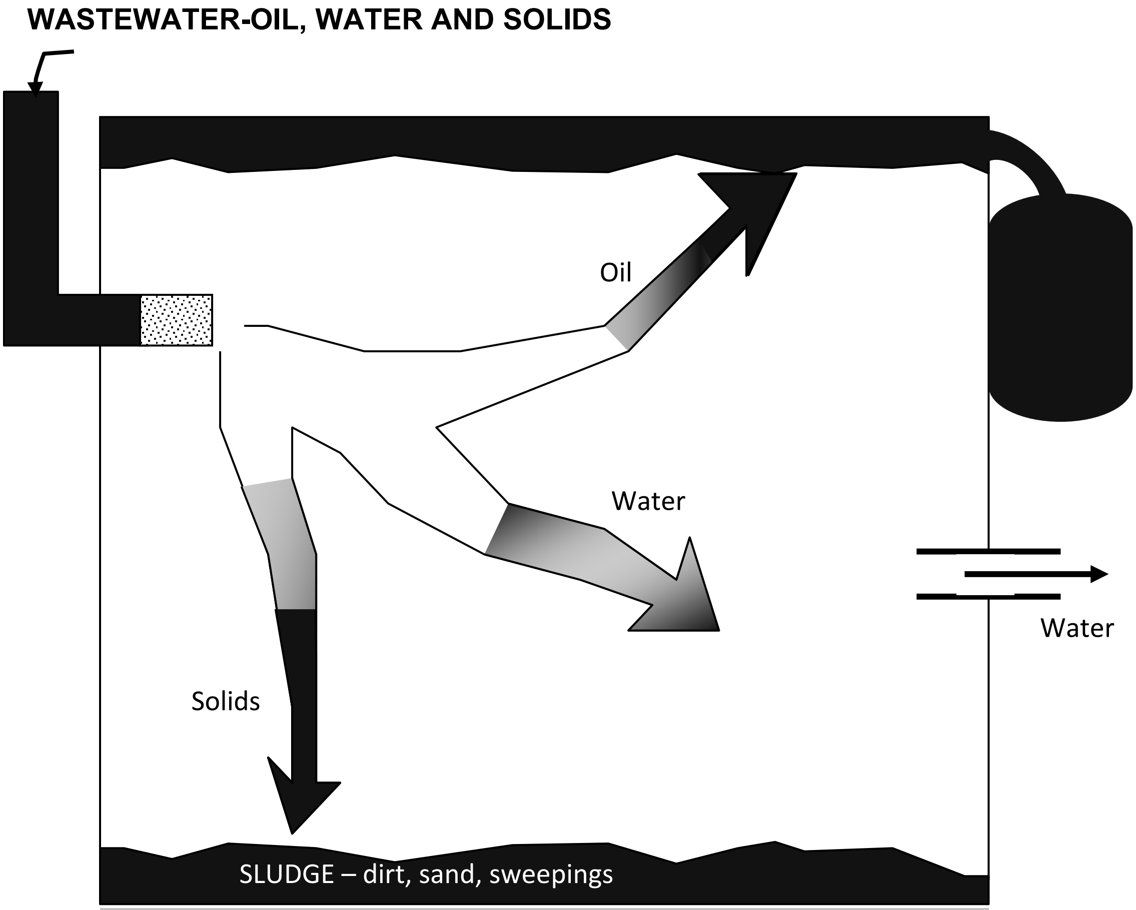
The central waste management unit (CWMU or TSDF) should include oil water separator (Figure 7.1) and slops tank. The engine spill, ballast/bilge and other oily wastes are transferred to separate the oil.

- ❑ separated oil is pumped to a storage tank and can be used as fuel of local vehicles as well as brick kilns,
- ❑ water is pumped to the nearby stream/river after treatment to MARPOL standards.

MARPOL 73/78 is one of the most important international marine environmental conventions. It was designed to minimize pollution of the seas, including dumping, oil and exhaust pollution. Its stated object is to preserve the marine environment through the complete elimination of pollution by oil and other harmful substances and the minimization of accidental discharge of such substances. Any discharge is prohibited, except when:

a) The ship is proceeding en route
b) The oil content of the effluent without dilution does not exceed 15 ppm
c) The ship has in operation oil filtering equipment with automatic 15 ppm stopping device
d) Bilge water is not mixed with oil cargo residue or cargo pump room bilges (on oil tankers).

Source: http://www.dynamic-ews.com/ (accessed 26 September 2016)




Oil water separator (OWS) treats wastewater by allowing substances lighter than water to float and substances heavier than water to sink. Some OWSs also have baffles, coalesces and oil skimmers to speed-up or enhance separation of these substances.

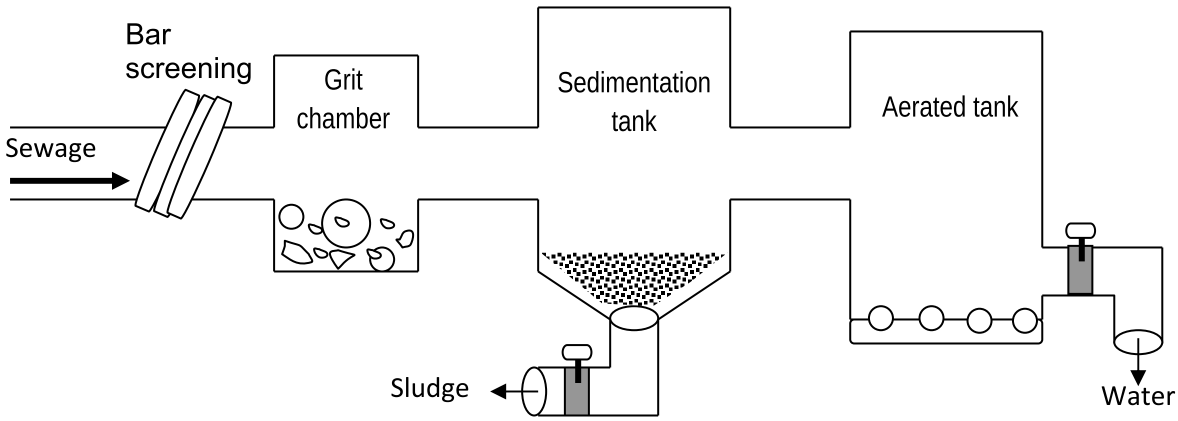
**Figure 7.1 Simplified diagram of oil-water separator operation**

*Domestic sewage management*

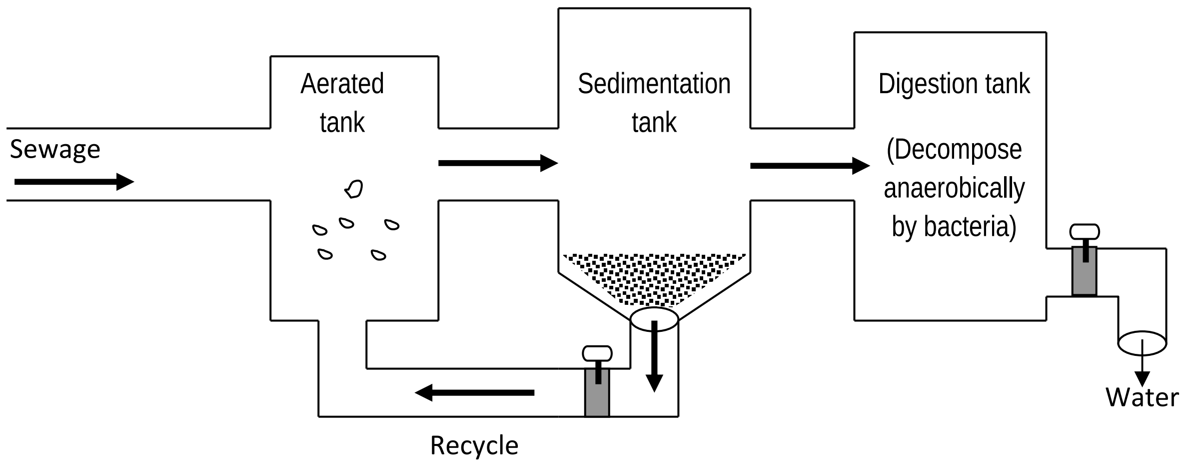
| | |
|---|---|
| **Description:**<br>Prevent discharge of contaminants associated with sewage handling.<br><br>**EMPs:**<br>❑ Adequate facilities need to be provided for the reception, disposal and treatment of sewage.<br>❑ Gravitational separation of water and sludge.<br>❑ Enhance bacterial decomposition inoculating known bacteria.<br>❑ Decompose the sludge to prepare organic manure to use in cropland, plant nursery, fish pond for phytoplankton growth, etc. | **Targeted activities**<br><br>Sewage collection<br><br>Sewage disposal & treatment<br><br>**Potential pollutants:**<br><br>Microbes<br><br>Biodegradable compounds<br><br>High BOD<br><br>**Target environmental media:**<br><br>Surface water<br><br>Soil<br><br>Air |

Sewage treatment may be by plant similar to commercial/residential design. Treatment plants (primary, secondary and tertiary) can be constructed as alternative options (Figure 7.2).The resulting wastewater is, after treatment, pumped to the river/stream. The non-harmful solid wastes can be used for low land filling.

(a) **Primary treatment:** Removal of floating materials e.g., box, wood, carton, etc.




(b) **Secondary treatment:** Wastes degraded by microbes.




(c) **Tertiary treatment: C**hemical treatment- the fluid is safely discharged and the sludge is used as manure.

i) Chlorination: To remove foul odour and microorganisms from the water
ii) Phosphate removal by:
  - culturing algae
  - sand filter
  - using lime
iii) Nitrate removal:
  - By algae and seaweed culture
  - Using high power trickling filter
  - Using $CaCO_3$
iv) Inorganic salt removal: By precipitation

**Figure 7.2 Simplified diagram of sewage treatment process**

### 7.3.5 Noise and vibration level management

| | |
|---|---|
| **Description:**<br>Ongoing varying types of dismantling activities will result in noise and vibrations.<br><br>**EMPs:**<br>❑ Diesel powered machinery, which are major source of noise in scrap yards, will be properly maintained as per maintenance schedule to prevent undesirable noise. Attention shall be paid towards rigorous maintenance of the silencers of diesel engines.<br>❑ Duty hours of operators of noisy machinery may be regulated to keep their noise exposure levels within limits.<br>❑ The monitoring programme must include location of the monitoring stations, procedures and frequency of measurements, reporting to BSBA.<br>❑ The monitoring station should be located at the dwelling closest to the ship dismantling facility.<br>❑ Meteorological conditions should also be recorded as they may affect the spread of noise.<br>❑ The highest noise level will most likely be measured at a monitoring station located down-wind from the ship dismantling facility.<br>❑ Influence from other sources in the area (e.g. traffic, industry) should be evaluated, since these could affect the resulting noise level at the monitoring stations. | **Targeted activities**<br><br>Noise measurement<br><br>Vibration measurement<br><br>Use appropriate equipment<br><br>**Potential pollutants:**<br><br>Noise<br><br>Vibration<br><br>**Target environmental media:**<br><br>Air<br><br>Earth/soil<br><br>Water |

## 7.4 Monitoring requirements

Monitoring of relevant aspects of environmental performance during ship recycling is vital and important to ensure continued compliance with environmental management and mitigation plan as well as to demonstrate compliance with present and future standards relating to both environmental and operational key quality parameters performance of pollution control measures. This monitoring program is designed to ensure keeping up-to-date records/data of the environmental quality key parameters in printed form during operational activities of the yard with the help of necessary equipment/tool for taking precautionary measures timely in the advent of undesirable environmental impacts and deviation from prescribed standards and specific regulations.

Generally, monitoring involves repeated sampling and analysis of environmental and work place (ship recycling yards) samples. Besides this, to ensure the effectiveness of such kind of activity, sometime certain surveillance monitoring will be necessary. In this context, some of which will be conducted by the authorized personnel of the yard and some of the criteria could be inspected by the Bangladesh Government Regulatory Agency i.e. DoE as and when required, because they are empowered for surveillance monitoring with a view to examine levels of compliance on occasional or ad-hoc basis. Therefore, ship recycling yards must maintain necessary skilled/trained manpower, tools and equipments in order to undertake both regular and surveillance monitoring program capable of satisfying monitoring requirements.

### 7.5 Monitoring indicators

The monitoring program includes of making systematic observation, collection, examination, measurement and evaluation of both physical view and chemical aspects of Environmental Quality Key Parameter's pollution levels in water, soil/sediment and air in and adjacent areas of ship screapping yards. The purpose is to provide an authentic record/data of the baseline water, soil and air quality along with oily wastes discharges, solid waste disposal and domestic sewage quality levels associated with the operational activities of the yards. The monitoring of the following 'Environmental Quality Key Indicators' will have to be carried out by the yards on regular or periodical basis as deemed necessary and be recorded for inspection and evaluation as and when necessary:

- Oily wastewater effluent discharges
- Ambient water and sediment quality
- Smoke emission to air
- Public complaints regarding impacts on flora and fauna.

**Table 7.1 Monitoring key parameters of water, soil/sediment and air in and adjacent areas of ship screapping yards**

| **Key parameters to be monitored: (I) Oily wastewater effluents discharge analysis** | | | |
|---|---|---|---|
| A | B | C | D |
| Samples of oily effluent to be collected from separator tank after treatment before discharge to the environment. | Routine analysis | Oil & grease, BOD, COD, TDS, TSS. | Report compilation for BSBA record. |
| **Key parameters to be monitored: (II) Ambient water quality analysis** | | | |
| A | B | C | D |
| Coastal water samples from selected sites within yards jurisdiction. | At least twice in a year (one in wet and other in dry season) | DO, BOD, COD, Oil & Grease, heavy metals, pesticides etc. | Report compilation for BSBA record. |
| **Key parameters to be monitored: (III) Ambient sediment quality analysis** | | | |
| A | B | C | D |
| Sediment samples from selected sites within yards jurisdiction. | At least twice in a year (one in wet and other in dry season) | Organic content, Oil & Grease, Nutrient, Metals, Pesticides, etc. | Report compilation for BSBA record. |
| **Key parameters to be monitored: (IV) Smoke emission to air** | | | |
| A | B | C | D |
| Emission mode | As and when required | SPM, SOx, NOx | Report compilation for BSBA record. |
| **Key parameters to be monitored: (V)** *Public complaints regarding impacts on flora and fauna will be handled appropriately.* | | | |

### 7.6 Cost of monitoring

Any charges levied would be a matter for local arrangement. They may take into account the type, size and category of the ship and whether the ship produced reduced quantities of ship-generated waste (Table 7.2) because of its environmental management, design, equipment or operation. The fees and how they have been calculated should be made clear to CWMU users to show that they are fair, transparent and non-discriminatory and reflect the costs of the facilities and services provided.

**Table 7.2 Assessment of ship-generated waste types and quantity**

**(a) General Information**

| | |
|---|---|
| Name of Ship | |
| Contact Person | |
| Designation | |
| Tonnage of ship | |
| Type of ship | Tanker/Container ship/Dry cargo/Passenger/Naval/Other |

**(b) Wastes to discharge**

| Waste Type | Quantity | Fees (Taka) |
|---|---|---|
| Dirty ballast water | | |
| Oily bilge water | | |
| Tank washing | | |
| Oily mixtures containing chemicals | | |
| Sludge from purification of fuel oil | | |
| Noxious liquid substances (Chemicals) | | |
| Paint chips | | |
| Cable cover/rubber | | |
| Sewage | | |
| Garbage | | |
| Others (please specify) | | |
| **Total** | | |

### 7.7 Management capacity

Selection of appropriate options for central waste management unit (CWMU/TSDF) for ship recycling yards at Chittagong, important factors are:

- the initial reception capacity (the amount and types that can be received from a yard, without causing undue delay);
- the processing and storage capacity;
- availability of land for construction of reception facilities and its accessories;
- the choice of treatment process;
- recycling and disposal options for the effluents from the treatment facility;
- construction, operation and maintenance cost
- reliability and simplicity in operation

## 7.8 Safety mitigation plan

Suitable safety and emergency procedures need to be formulated for implementation during operations tackling of emergency situations arising out of the proposed operations. Procedures for the following safety and emergency situations shall be formulated:

- Equipment failure during beaching or cutting of ship
- Fire
- Spillage of hazardous wastes
- Accidents during regular operations
- Possible danger due to storage of compressed gases (LPG, refrigerants)
- Possible danger due to spillage of fuel oil
- Natural disasters (earthquakes, tropical cyclone, tidal surge)

## 8. Emergency Response for Safety

General requirements would be covered under the headings set out below. Further details may be found in other SENSREC documents.

8.1 Fall protection
8.2 Fire prevention and protection
8.3 Rescue
8.4 Lifesaving materials
8.5 Hazardous material spills
8.6 Energy control
8.7 Medical facility
8.8 Worker medical qualifications
8.9 Sanitation
8.10 Materials handling
8.11 Crane services
8.12 Training
8.13 Communication

## 9. Stakeholder Consultation

### 9.1 Objectives of stakeholder consultation

Stakeholder consultation of ship recycling involves the development of relationships over the long term. It results in a relationship of mutual benefit and enables us to identify trends and emerging challenges which are currently or will in the future impact on the ship recycling industry. Listening to stakeholder concerns and feedback is a valuable source of information that can be used to improve ship recycling industry, and help to identify and control external risks. It can also form the basis for future collaboration and partnerships. Consultation enables us to identify and monitor trends, challenges and perceptions over time. It therefore helps us to:

- Identify and track needs and expectations
- Identify and track perceptions and attitudes
- Provide feedback on specific planned developments
- Evaluate implementations and actions

### 9.2 Consultation process

Consultation process is an opportunity for stakeholders to get information as well as give feedback. Stakeholders can use the opportunity to instruct the organization about the local context in which a project will take place, to raise issues and concerns, ask questions, and potentially help shape the project by making suggestions for the organization to consider and respond to. Therefore, a planned process for consultation needs to be in place, commencing with clear objectives about what is to be achieved. The process can be ongoing and iterative, a one-off consultation related to a specific discrete issue, or a series of consultations related to a particular project. The process involves four steps such as, planning, process, presentations and promise (the 4 Ps) (source: https://www.b2binternational.com/publications/stakeholder-research).

In the **planning** stage, the aims and objectives need to be clarified, along with identification of the usefulness of the process, i.e. the likelihood that stakeholder views will be incorporated into strategic planning. Subsequently, the **process** stage is the "doing" stage; this involves carrying out the consultation. The next stage, **presentation**, is concerned with the analysis and the reporting of the data. The data will need to be analyzed and reporting prepared for the relevant audiences i.e. back to the organization, to policy makers, investors, and traders but also feedback to those who have engaged in the process and taken part. The final stage relates to actions as a result of the consultation; the **promise.** Part of the process of engaging with stakeholders is the investment in a longer-term relationship of mutual benefit and trust for the establishment of ship recycling at Chittagong.

### 9.3 Stakeholder consultation technique/method

In the field of ship recycling yards, participation of relevant/key stakeholder is important not only for gathering information, but also for confirmation of "known" facts and for ensuring participation in decision making and management interventions. The use of participatory tools offers a good opportunity to get a comprehensive and authentic insight in actual situations including actions, conversations and physical descriptions [138]. Therefore, facts and figures on various aspects of the ship recycling (such as beaching, cutting, carrying, trading, etc.) were collected following focus group discussions (FGD) and key informant interviews (KII) described by Pido (1995)[139], Pido et al. (1996)[140], Townsley (1996)[141], IIRR (1998)[142] and Hossain et al. (2004)[143]. Moreover, information on the natural environment, local customs and lifestyle of the inhabitants were also obtained through semi-structured interview. Fishermen's group, wetland users, government agencies (e.g. MoI, DoE), NGOs, and experts were included in the consultation process.

### 9.4 Stakeholders consulted

BSBA officials, yard owners, managers, worker/labour contractors, traders (ship-borne materials), local residents and nearby fishing communities were consulted as stakeholders. Additionally, academia and researchers, government officials, NGOs representatives and social activists were also consulted.

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### 9.5 Stakeholder concerns and recommendations

| Stakeholder groups | Concerns | Recommendations |
|---|---|---|
| **BSBA officials** | Cost-effective business | Capacity, infrastructure and monetary support |
| **Yard Managers** | Smooth operation of ship yard activities | Train workers, necessary support to comply rules and regulations |
| **Workers/labour contractors** | Wage rate, timely payment, leave, medical care, personal protective equipment | Safe and secure working environment, job security, competitive remuneration |
| **Traders(ship-borne materials)** | Uninterrupted supply chain, cost-effective business | Market demand |
| **Local residents** | Access right, environmental protection | Designated zone, environmental care |
| **Local fishers** | Access right, environmental protection | Designated zone |
| **Academic and researchers** | Knowledge generation, science, data | Research, dissemination, education, training |
| **Government officials** | Environmental protection, health and safety provisions, and working conditions | Compliance of rules and regulations |
| **NGOs representative, environmental activists, social activists** | Environmental protection, health and safety provisions, and working conditions | Compliance of rules and regulations, reliable certification procedure i.e. green yards |

## 10. Conclusions and Recommendations

### 10.1 Conclusions

Bangladesh has a well-developed set of environmental policies, Acts and Rules that deal with industrial pollution of water, soil and air. In recent years, a number of the ship recycling yards have invested in upgrades to their facilities. Waste treatment facilities including oil-water separator, incinerator, and sewage tanks are in the process of being established. It is hoped that an environment monitoring laboratory and a landfill site will also be established in the near future.

Some basic parameters of water and air quality in ship recycling areas are now being routinely monitored by the Department of Environment. However, concentration of heavy metals, PCBs and TBTs in water, sediment and biological samples need to be monitored in a regular and consistent manner to assess potential pathways of bioaccumulation and bio-magnification.

From this study it has been evident that many variables for a robust understanding of the impacts of the ship recycling industry on the environment are unknown. These variables include, for example, concentrations and species variations of pollutants in different sub-systems, land-use change, segregation of pollution load from other (non-ship recycling) activities, biodiversity of the area, local oceanography, water current and circulation, discharge through streams and canals etc. This indicates the necessity for a carefully designed, broader systematic study on these aspects of the environment in this area.

Observations indicate that conventional pollution and concentrations of heavy metals in and around the yards may not be as significantly detrimental to the environment as initially indicated from other reports. Their concentrations in the ambient environment seems to be within tolerable limits of the ecosystems and biotic communities (albeit that there appear to be differences between water and sediment values). The reasons for this require further investigation, whether due to being lower emissions, retention within the beach dismantling areas, tidal mixing and dispersion, impacts of seasonal weather variation (dilution effects) or sub-optimal sampling location selection in other studies, or in this study. This requires a detailed systematic investigation.

Displacement and subsidence of earth materials in the yards is evident through field visits and stakeholders consultation. Thus, historical trends of coastal erosion due to shipyards need to be assessed considering the quantity of materials displaced. In this case, satellite data analysis with geo-spatial modelling and subsequent ground observation can be a useful technique.

The environmental attributes need to be monitored to ensure proper implementation and effectiveness of various mitigation measures adopted during operation. In this connection, short-term monitoring of surrounding environment (air, water, soil) as well as long term monitoring of biota are essential, as most of the pollutants (metals, PCBs, TBTs) have characteristics of bioaccumulation and biomagnification through the food chain.

Development of laboratory facilities for environmental monitoring would assist in progressing these aims.

### 10.2 Recommendations

- An improved understanding of the environmental context of the ship recycling area at Sitakunda, in terms of the coastal marine and land environment, is required to be able to fully appreciate its potential impacts in comparison with other possible inputs for industry and agriculture etc.;
- Additional study of the range and distribution of biota over time is needed particularly to identify useful indicator species and those of local importance including fish and shrimp species;
- An improved understanding of the separate contribution to environmental pollution made by other industry, agriculture etc. is needed to be able to differentiate this from ship recycling per se, especially where the same substances may be being released (e.g. heavy metals, oils and grease, paints);
- Further development of monitoring programmes for environmental pollution with establishment of time series measurements will help to elucidate the causes and better assess mitigation efforts;
- A “Shipyard zone” demarcated in the coastal environment, limiting the activities in a certain area would assist in considering potential environmental impacts and regulatory mechanism;
- Releases to the environment from ship recycling can be reduced with the installation of further treatment plant for ship breaking and recycling (such as oil-water separators, incinerator, hazardous waste treatment plant)as well as engineered landfill sites for treated materials.

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**Annex A**
**Seawater quality of ship recycling yards at Sitakunda, Chittagong (source: DoE)**

| Location | Year | pH | EC (µS/cm) | TDS (mg/l) | Chloride (mg/l) | DO (mg/l) | COD (mg/l) | Oil & grease (mg/l) | $NH_3$ (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Yard A | 2016 | 8.1 | 29800 | 14900 | 10960 | 5.8 | 359 | 6.5 | 0.21 |
| Yard B | | 8.8 | 27118 | 13559 | 8700 | 5.9 | 321 | 5.9 | 0.15 |
| Yard C | | 8.6 | 28660 | 14330 | 10120 | 6.2 | 218 | 6 | 0.16 |
| Yard D | | 7.6 | 30621 | 16120 | 10295 | 5.2 | 392 | 4.5 | 0.29 |
| Yard E | | 7.92 | 32126 | 16063 | 11223 | 5.85 | 355 | 5.1 | 0.27 |
| Yard F | | 7.95 | 32343 | 15923 | 11621 | 5.3 | 379 | 6.3 | 0.22 |
| Yard G | | 7.3 | 3760 | 1693 | 1190 | 5.3 | 312 | 4.3 | 0.19 |
| Yard H | | 7.6 | 30210 | 15105 | 11011 | 5.6 | 377 | 5 | 0.2 |
| Yard I | | 7.5 | 30870 | 15435 | 10911 | 5.5 | 301 | 4.8 | 0.18 |
| Yard J | | 7.75 | 7980 | 4039 | 5690 | 6.62 | 570 | 6 | 0.12 |
| Yard K | | 7.86 | 26524 | 13262 | 8956 | 5.9 | 412 | 7.8 | 0.16 |
| Yard L | | 7.1 | 24230 | 12115 | 9630 | 5.1 | 360 | 4.2 | 0.15 |
| Yard M | | 7.3 | 3760 | 1693 | 1190 | 5.3 | 312 | 4.3 | 0.19 |
| Yard N | | 7.63 | 30218 | 15109 | 11016 | 5.7 | 382 | 5.5 | 0.2 |
| Yard O | | 7.7 | 34230 | 17115 | 13452 | 5.6 | 440 | 6 | 0.2 |
| Average | | 7.78 | 24830 | 12431 | 9064 | 5.7 | 366 | 5.5 | 0.19 |

| Location | Year | pH | EC (µS/cm) | TDS (mg/l) | Chloride (mg/l) | DO (mg/l) | COD (mg/l) | Oil & grease (mg/l) | $NH_3$ (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Yard A | 2015 | 7.2 | 5200 | 2600 | 1810 | 6.4 | 39 | 4.5 | 0.17 |
| Yard B | | 7.7 | 22300 | 11150 | 9100 | 5.6 | 379 | 6.8 | 0.2 |
| Yard C | | 7.5 | 10240 | 5128 | 2815 | 5.4 | 272 | 5.1 | 0.19 |
| Yard D | | 7.9 | 1928 | 895 | 4824 | 6.9 | 239 | 5.6 | 0.12 |
| Yard E | | 7.5 | 10424 | 5212 | 3610 | 5.6 | 95 | 5.4 | 0.18 |
| Yard F | | 7.7 | 4790 | 2403 | 1610 | 6.5 | 410 | 4.2 | 0.12 |
| Yard G | | 7.91 | 34240 | 17120 | 13460 | 5.5 | 476 | 6.4 | 0.21 |
| Yard H | | 7.95 | 34260 | 17130 | 13462 | 5.1 | 475 | 6 | 0.22 |
| Yard I | | 7.96 | 34280 | 17140 | 13463 | 5.3 | 481 | 6.2 | 0.23 |
| Yard J | | 7.9 | 34260 | 17130 | 13460 | 5.3 | 470 | 6.2 | 0.22 |
| Yard K | | 7.81 | 34240 | 17120 | 13432 | 5.4 | 459 | 5.9 | 0.2 |
| Yard L | | 8.2 | 36130 | 18070 | 14126 | 5.3 | 478 | 6.5 | 0.22 |
| Yard M | | 8.1 | 36160 | 18080 | 14120 | 5 | 476 | 6.3 | 0.19 |
| Yard N | | 7.5 | 14210 | 7105 | 4912 | 5.4 | 180 | 5.4 | 0.17 |
| Yard O | | 7.6 | 14218 | 7109 | 4910 | 5.5 | 186 | 5.4 | 0.15 |
| Average | | 7.76 | 21792 | 10893 | 8608 | 5.6 | 341 | 5.7 | 0.19 |

| Location | Year | pH | EC (µS/cm) | TDS (mg/l) | Chloride (mg/l) | DO (mg/l) | COD (mg/l) | Oil & grease (mg/l) | $NH_3$ (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Yard A | 2014 | 7.6 | 18462 | 9231 | 5857 | 5.5 | 280 | 5.5 | 0.18 |
| Yard B | | 7.74 | 22420 | 11210 | 9101 | 5.5 | 377 | 7.1 | 0.26 |
| Yard C | | 7.7 | 22660 | 11330 | 9102 | 5.5 | 336 | 6.8 | 0.25 |
| Yard D | | 7.6 | 18460 | 9230 | 5858 | 5.4 | 281 | 5.7 | 0.2 |
| Yard E | | 7.64 | 4106 | 2111 | 1297 | 5.2 | 114 | 4 | 0.1 |
| Yard F | | 7.6 | 10420 | 5210 | 3615 | 5.4 | 93 | 5.2 | 0.17 |
| Yard G | | 7.54 | 22624 | 11303 | 9126 | 5.5 | 389 | 5.6 | 0.2 |
| Yard H | | 7.6 | 21124 | 10562 | 8872 | 5.5 | 385 | 5.3 | 0.18 |
| Yard I | | 7.62 | 21008 | 10500 | 8834 | 5.5 | 383 | 5.4 | 0.19 |
| Yard J | | 7.68 | 20880 | 10440 | 8754 | 5.5 | 385 | 5.6 | 0.21 |
| Yard K | | 7.81 | 24684 | 12345 | 8310 | 5.4 | 309 | 5.2 | 0.24 |
| Yard L | | 7.63 | 25640 | 12720 | 8464 | 5.2 | 311 | 5.2 | 0.15 |
| Yard M | | 7.74 | 22420 | 11210 | 9101 | 5.5 | 341 | 5.1 | 0.2 |
| Yard N | | 7.82 | 31430 | 15715 | 11307 | 5.5 | 391 | 7 | 0.2 |
| Yard O | | 7.54 | 22624 | 11303 | 9126 | 5.5 | 389 | 5.6 | 0.2 |
| Average | | 7.66 | 20597 | 10295 | 7782 | 5.4 | 318 | 5.6 | 0.20 |

| Location | Year | pH | EC (µS/cm) | TDS (mg/l) | Chloride (mg/l) | DO (mg/l) | COD (mg/l) | Oil & grease (mg/l) | $NH_3$ (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Yard A | 2013 | 7.83 | 4630 | 2316 | 1505 | 5.6 | 112 | 4 | 0.15 |
| Yard B | | 7.6 | 26800 | 13400 | 9230 | 5.4 | 326 | 6 | 0.21 |
| Yard C | | 7.2 | 12590 | 6290 | 4011 | 5.3 | 275 | 6 | 0.21 |
| Yard D | | 7.84 | 30800 | 15400 | 13112 | 5.2 | 402 | 6.2 | 0.23 |
| Yard E | | 7.52 | 15400 | 7900 | 5492 | 5.3 | 365 | 6 | 0.19 |
| Yard F | | 7.76 | 3720 | 1867 | 1311 | 5.4 | 182 | 5.2 | 0.17 |
| Yard G | | 7.71 | 3864 | 1934 | 1308 | 5.5 | 161 | 5.5 | 0.17 |
| Yard H | | 7.68 | 4002 | 2001 | 1178 | 5.5 | 137 | 4.2 | 0.16 |
| Yard I | | 7.83 | 4630 | 2316 | 1505 | 5.4 | 112 | 4 | 0.15 |
| Yard J | | 7.92 | 24480 | 12240 | 8336 | 5.4 | 336 | 5.8 | 0.19 |
| Yard K | | 7.85 | 4632 | 2317 | 1506 | 5.5 | 113 | 4.2 | 0.17 |
| Yard L | | 7.6 | 15330 | 7615 | 5411 | 5.4 | 259 | 5.3 | 0.19 |
| Yard M | | 7.9 | 28640 | 14320 | 11432 | 5.1 | 371 | 6 | 0.19 |
| Yard N | | 7.6 | 30460 | 15230 | 10874 | 5.3 | 385 | 5.5 | 0.21 |
| Yard O | | 7.7 | 28700 | 14350 | 10120 | 5.4 | 339 | 5.2 | 0.18 |
| Average | | 7.70 | 15912 | 7966 | 5755 | 5.4 | 258 | 5.3 | 0.18 |

| Location | Year | pH | EC (µS/cm) | TDS (mg/l) | Chloride (mg/l) | DO (mg/l) | COD (mg/l) | Oil & grease (mg/l) | $NH_3$ (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Yard A | 2012 | 8 | 26200 | 13100 | 11710 | 5.2 | 395 | 6.4 | 0.2 |
| Yard B | | 8 | 26400 | 13200 | 11720 | 5.1 | 398 | 6.5 | 0.21 |
| Yard C | | 7.7 | 22800 | 11400 | 9100 | 5.3 | 305 | 6 | 0.19 |
| Yard D | | 7.94 | 26400 | 13200 | 10870 | 5.1 | 429 | 6 | 0.22 |
| Yard E | | 7.9 | 15600 | 12800 | 9660 | 5.2 | 439 | 6.2 | 0.23 |
| Yard F | | 7.81 | 22820 | 11410 | 9180 | 5 | 415 | 6.6 | 0.21 |
| Yard G | | 7.8 | 22400 | 11200 | 9820 | 5.1 | 432 | 6.5 | 0.22 |
| Yard H | | 8.2 | 21880 | 10940 | 8518 | 5.3 | 332 | 6.8 | 0.22 |
| Yard I | | 7.92 | 36920 | 18460 | 12332 | 5.7 | 439 | 5.2 | 0.19 |
| Yard J | | 7.82 | 4120 | 2060 | 1150 | 5.3 | 142 | 6.2 | 0.21 |
| Yard K | | 7.94 | 36920 | 18460 | 12334 | 5.6 | 446 | 5.5 | 0.19 |
| Yard L | | 7.72 | 3024 | 1512 | 917 | 5.6 | 102 | 7.2 | 0.19 |
| Yard M | | 7.9 | 36820 | 18410 | 12320 | 5.7 | 432 | 4.1 | 0.16 |
| Yard N | | 7.7 | 4206 | 2103 | 1231 | 5.2 | 247 | 6.5 | 1.2 |
| Yard O | | 7.85 | 4212 | 2106 | 1306 | 5.2 | 169 | 5.6 | 0.18 |
| Average | | 7.88 | 20715 | 10691 | 8145 | 5.3 | 341 | 6.1 | 0.27 |

**Annex B.**
**Air quality and sound quality data of ship recycling yards, Sitakunda (source: DoE)**

| Location | Year | SPM (µg/m$^3$) | SOx (µg/m$^3$) | NOx (µg/m$^3$) | Sound level (dBa) |
|---|---|---|---|---|---|
| Yard A | 2016 | 166 | 5.5 | 9.5 | 70 |
| Yard B | | 169 | 6.1 | 8.5 | 71 |
| Yard C | | 181 | 6.1 | 9.2 | 72 |
| Yard D | | 171 | 6 | 9.5 | 69.5 |
| Yard E | | 172 | 6.1 | 9.6 | 71.5 |
| Yard F | | 169 | 6.5 | 9.5 | 71 |
| Yard G | | 171 | 3.2 | 7.4 | 73.1 |
| Yard H | | 179 | 3.4 | 8.1 | 73 |
| Yard I | | 122 | 5.5 | 8.8 | 70 |
| Yard J | | 130 | 5.6 | 9.1 | 71 |
| Yard K | | - | - | - | - |
| Yard L | | 174 | 6.5 | 9.8 | 73 |
| Yard M | | 176 | 4.1 | 9 | 72.3 |
| Yard N | | - | - | - | - |
| Yard O | | 142 | - | - | 72.5 |
| Average | | 163 | 5.4 | 9 | 72 |

| Standard limit | Below 200 | Below 80 | Below 100 | Below 75 |
|---|---|---|---|---|

| Location | Year | SPM (µg/m³) | SOx (µg/m³) | NOx (µg/m³) | Sound level (dBa) |
|---|---|---|---|---|---|
| Yard A | 2015 | 170 | 3 | 5 | 71.8 |
| Yard B | | 162 | 4 | 7 | 71.6 |
| Yard C | | 173 | 5 | 7 | 62.6 |
| Yard D | | 126 | 4.2 | 10 | 71 |
| Yard E | | 177 | - | - | 67.6 |
| Yard F | | 127 | - | - | 63.4 |
| Yard G | | 172 | - | - | 68 |
| Yard H | | 162 | - | - | 64.2 |
| Yard I | | 176 | - | - | 71.3 |
| Yard J | | 160 | - | - | 67.3 |
| Yard K | | 167 | - | - | 72.1 |
| Yard L | | - | - | - | - |
| Yard M | | 169 | - | - | 69.3 |
| Yard N | | 131 | - | - | 62.5 |
| Yard O | | 145 | - | - | 64.5 |
| Average | | 158 | 4.1 | 7.3 | 68 |

| Location | Year | SPM (µg/m³) | SOx (µg/m³) | NOx (µg/m³) | Sound level (dBa) |
|---|---|---|---|---|---|
| Yard A | 2014 | 155 | - | - | 64.3 |
| Yard B | | 150 | 7.1 | 14.2 | 69 |
| Yard C | | 162 | 7.1 | 13.5 | 67 |
| Yard D | | 154 | - | - | 64.3 |
| Yard E | | 110 | - | - | 64 |
| Yard F | | 171 | - | - | 62.5 |
| Yard G | | 138 | - | - | 63.2 |
| Yard H | | 154 | - | - | 64.3 |
| Yard I | | 145 | - | - | 63.2 |
| Yard J | | 149 | - | - | 63.6 |
| Yard K | | 161 | 6.2 | 14.1 | 64 |
| Yard L | | 146 | 5.4 | 12 | 62 |
| Yard M | | 169 | 12.4 | 18.4 | 66 |
| Yard N | | 160 | 7.2 | 14.3 | 65 |
| Yard O | | 142 | - | - | 62.3 |
| Average | | 151 | 7.6 | 14.4 | 64 |

| Location | Year | SPM (µg/m³) | SOx (µg/m³) | NOx (µg/m³) | Sound level (dBa) |
|---|---|---|---|---|---|
| Yard A | 2013 | 142 | 5 | 9 | 62 |

| | | | | | |
|---|---|---|---|---|---|
| Yard B | | 155 | 7.2 | 14 | 62 |
| Yard C | | 151 | 6 | 15.3 | 62 |
| Yard D | | 159 | 6.6 | 17 | 63 |
| Yard E | | 92 | 5 | 7 | 55 |
| Yard F | | 156 | 5 | 11 | 63 |
| Yard G | | 122 | 4 | 10 | 61 |
| Yard H | | 124 | 4.2 | 10.3 | 61 |
| Yard I | | 159 | 7.5 | 17.4 | 65 |
| Yard J | | 168 | 9 | 21 | 67 |
| Yard K | | 156 | 7.2 | 15.4 | 63.2 |
| Yard L | | 92 | 5 | 7 | 55 |
| Yard M | | 168 | 7.5 | 19 | 64 |
| Yard N | | 139 | 5.5 | 11.4 | 61 |
| Yard O | | 134 | 5.4 | 11 | 61 |
| Average | | 141 | 6.0 | 13.1 | 62 |

| Location | Year | SPM (µg/m$^3$) | SOx (µg/m$^3$) | NOx (µg/m$^3$) | Sound level (dBa) |
|---|---|---|---|---|---|
| Yard A | 2012 | 158 | 6.2 | 11.3 | 64 |
| Yard B | | 155 | 7 | 10 | 62 |
| Yard C | | 156 | 8 | 10.4 | 63 |
| Yard D | | 152 | 7.4 | 15 | 63 |
| Yard E | | 152 | 7.4 | 15 | 63 |
| Yard F | | 144 | 5.5 | 10.6 | 63 |
| Yard G | | 150 | 6.3 | 12 | 64 |
| Yard H | | 110 | 4.5 | 7 | 53 |
| Yard I | | 160 | 6 | 18 | 63 |
| Yard J | | 146 | 6 | 17 | 65 |
| Yard K | | 120 | 4 | 10 | 61 |
| Yard L | | 135 | 5.4 | 15 | 64 |
| Yard M | | 140 | 4.4 | 10 | 63 |
| Yard N | | 34 | ND | ND | 49 |
| Yard O | | 165 | 8 | 17 | 66 |
| Average | | 138 | 6.2 | 12.7 | 62 |


Photo: Roy Watkinson