Assessment of Water Quality in Surface Water of Shipbreaking Sites at Kumira Ghat, Sitakunda, Bangladesh

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ABSTRACT

The Bay of Bengal ecosystem is blessed with vast resources. A major part of the people living nearby coastal areas depends on marine resources for their livelihood. These resources are facing risks due to pollution caused by shipbreaking activities. The present study was conducted to investigate the water quality adjacent to shipbreaking sites of Kumira Ghat, Sitakunda, Chittagong, Bangladesh and was carried out by field measurements of DO, pH, TDS, EC, temperature; BOD and heavy metals (Cd, Pb, Hg, Cu and Fe) in the laboratory while heavy metals followed by Atomic Absorption Spectrometry (AAS) methods of 5 water samples. The values of DO, pH, TDS, EC, BOD and temperature ranged from 7.16 to 7.43 mg/l, 8.02 to 8.04, >10000 mg/l, 5752 to 6745 µS/cm, 1.4 to 2.76 mg/l, 26.87 to 27.6 °C, respectively. The values of Temperature, pH and BOD were within the standard limit but TDS and EC values were exceeding the standard level given by WHO for surface water. According to the study, the water was contaminated with Cd (0.003 to 0.007 mg/l), Pb (0.01 mg/l), Hg (<0.001), Cu (<0.1 mg/l) and Fe (25.2 to 53.6 mg/l). The amount of Fe crossed the standard level for surface water (0.1-1.0 mg/l) given by WHO. Finally, it was found that water was alkaline based on pH range. The ionization capacity of the water was very high because of high TDS and EC values. Positive correlations were found among pH and Temperature, BOD and Temperature, BOD and pH, Fe and EC and negative correlations were found among EC and Temperature, EC and BOD, Fe and Temperature and Fe and BOD.

Keywords: water quality, shipbreaking, physicochemical parameter, heavy metal, sitakunda area

ABSTRAK

Ekosistem Teluk Benggala diberkati dengan sumber daya yang melimpah. Sebagian besar masyarakat yang tinggal di sekitar wilayah pesisir bergantung pada sumber daya laut untuk mata pencaharian mereka. Sumber daya ini menghadapi risiko akibat pencemaran yang disebabkan oleh aktivitas kerusakan kapal. Penelitian ini dilakukan untuk menyelidiki kualitas air yang berdekatan dengan lokasi pemecah kapal di Kumira Ghat, Sitakunda, Chittagong, Bangladesh dan dilakukan dengan pengukuran lapangan DO, pH, TDS, EC, suhu; BOD dan logam berat (Cd, Pb, Hg, Cu dan Fe) di laboratorium sedangkan logam berat dilanjutkan dengan metode Spektrometri Serapan Atom (SSA) sebanyak 5 sampel air. Nilai DO, pH, TDS, EC, BOD dan suhu berkisar antara 7,16 hingga 7,43 mg / l, 8,02 hingga 8,04,> 10.000 mg / l, 5752 hingga 6745 µS / cm, 1,4 hingga 2,76 mg / l, 26,87 hingga 27,6 °C, masing-masing. Nilai Temperatur, pH dan BOD berada dalam batas standar tetapi nilai TDS dan EC melebihi standar yang diberikan WHO untuk air permukaan. Menurut penelitian, air terkontaminasi dengan Cd (0,003 sampai 0,007 mg / l), Pb (0,01 mg / l), Hg (<0,001), Cu (<0,1 mg / l) dan Fe (25,2 sampai 53,6 mg / l). l). Jumlah Fe melebihi standar air permukaan (0,1-1,0 mg / l) yang diberikan oleh WHO. Akhirnya,

ditemukan bahwa air bersifat basa berdasarkan kisaran pH. Kapasitas ionisasi air sangat tinggi karena nilai TDS dan EC yang tinggi. Korelasi positif ditemukan antara pH dan Temperatur, BOD dan Temperatur, BOD dan pH, Fe dan EC dan korelasi negatif ditemukan antara EC dan Temperatur, EC dan BOD, Fe dan Temperatur dan Fe dan BOD.

Kata Kunci: kualitas air, kerusakan kapal, parameter fisika-kimia, logam berat, sitakunda

INTRODUCTION

During ship breaking activity different types of heavy metal entering into the surface water and fishes through water flow. Heavy metal also accumulated by human body through food chain. As a result heavy metal can affect the physiological state of human body. Ship breaking is the process of breakdown an obsolete vessel's structure for scrapping which includes a wide range of activities, from removing all equipments cutting down the ship's infrastructure (OSHA, 2001). Since 1984, Bangladesh has developed one of the largest ship breaking industries in the world (Kutub et al, 2017). For fulfilling its national demands for steel and iron Bangladesh relies on ship scrapping (Hossain et al, 2008).

Ship breaking is a challenging process, due to the structural complication of ships and the many environmental, safety, and health injuries involved (OSHA, 2001). About 50,000 people have involved directly and all over 200,000 people relies on scrapping activities including the indirect employment created by re-fabrication, recycling and distribution (Hossain et al, 2008). At present there are 24 ship breaking yards in Sitakunda region and the area is enlarged from over 14 km along Fauzdarhat to Kumira coast (YPSA, 2005). Each year 60-65 ships are either being damaged or used for the dismantling process (SHED, 2002).

The main pollutants from ship breaking were heavy metals, petroleum hydrocarbons and other contaminants. Among all these pollutants, petroleum hydrocarbons and heavy metals were the most important because of their toxicity and persistence (Hasan et al, 2013). There are some fundamental heavy metals, such as Fe, Zn, and Cu required for both aquatic organisms and the human body. But they have prolonged exposure to the excess level of these metals could be toxic. On the hostile, there are some nonessential toxic metals such as As, Cd and Pb with no known potential benefits for a human being (Wei et al, 2014). The area is severely fallen down with loss of its physical, chemical and biological characteristics. The removal processes required, generate debris and wastes that itself represent harmful to the environment and consequently to human health (Muhibbullah, 2013).

The shipping industry has a probably negative impact on the marine environment and some economic disadvantages. But there is no appropriate integrated system for the recycling or reusing of ship- related materials. At the time of ship recycling process different type of heavy metal discharge into marine water body like Cd, Pb, Hg, Ni, Fe, Co, Zn, etc and also Asbestos. These heavy metals deprave marine water bodies and also marine habitats Chang et al, 2010). As Sitakunda area has the largest number of ship breaking yards in Bangladesh, water pollution problem is getting very alarming here. So, the study aimed to investigate the water quality parameters and heavy metal concentration in surface water adjacent to ship breaking yard at Kumira ghat, Sitakunda, Chittagong, Bangladesh.

MATERIALS AND METHOD

Location of The Study Area
The water samples of the Ship breaking yard was collected from Kumira Ghat, Sitakunda Upazila in Chittagong district located at the south eastern part of Bangladesh where most of

the Ship breaking and Ship recycling Industries are located. The study area (Fig. 1) is 10 km away from the Chittagong city located between the latitudes 22.48078ºN and longitudes 91.70726ºE. Location of the sampling points were Point-1 (Latitudes: 22.302662ºN and Longitudes: 91.412386ºE), Point-2 (Latitudes: 22.302041ºN and Longitudes: 91.412769ºE), Point-3 (Latitudes: 22.301088ºN and Longitudes: 91.413520ºE), Point-4 (Latitudes: 22.30239ºN and Longitudes: 91.413923ºE) and Point-5 (Latitudes: 22.295284ºN and Longitudes: 91.414484ºE). Total distance of the study area is approximately 750 m.

Water Sampling

To analyze water quality a 1000 ml of water was collected by plastic bottles with double stoppers from each sampling station. Before sampling, the bottles were cleaned and washed with a detergent solution and treated with 5% HNO_3 overnight. The bottles were finally rinsed with deionized water and dried. After sampling, the bottles were screwed carefully and marked with the respective identification number. Temperature, DO, pH, EC and TDS were measured at the collection spots for all water samples. BOD was measured at the laboratory of Department of Environmental Science and Resource Management, Mawlana Bhashani Science and Technology University and heavy metals were analyzed at Institute of National A006 Ealytical Research and Service (INARS), BCSIR Laboratories, Dhaka.

Sample Analysis

The Dissolved Oxygen (DO) value of the water samples were measured by using a digital DO meter (Lutron, DO-5509), BOD measured by Winkler's Iodometric Method, EC values were determined by using digital EC meter (HM Digital), TDS value measured by using TDS meter (HM Digital) and Temperature by using digital thermometer.

Figure 1. Map of the study area (Sitakunda, Chittagong, Bangladesh)

To analyze heavy metals at first 100 mL water sample was taken in a beaker by using a calibrated pipette. Then 4-5 mL concentrated HNO_3 was added in it and the beaker was put on the hot-plate for digestion. After proper digestion, the sample was taken in a 100 mL volumetric flask and it was filled with distilled water up to the mark. Then it was filtered with

a filter paper (Whatman Qualitative 1) and preserved in a container. Pb, Cd concentrations of water samples were analyzed by using Zeeman Atomic Absorption Spectrometer (Model: Varian, AA 240Z and Method: APHA 3111.B), Hg concentration determined by using Cold Vapor Hydride Generation Atomic Absorption Spectrometer (Model: Varian, AA 220FS and Method: APHA 3112.B), Cu concentrations measured by using Flame Atomic Absorption Spectrometer (Model: Varian, AA 240FS and Method: APHA 2340.C) and Fe concentrations of water samples were analyzed by using Flame Atomic Absorption Spectrometer (Model: Varian, AA 240FS and Method: APHA 3111.B).

RESULTS AND DISCUSSION

Physicochemical Parameters

DO

Dissolved oxygen (DO) refers to oxygen gas that is dissolved in water. Atmospheric air and photosynthetic planktons are the origins of DO in water (Kane et el, 2015). In present study the average value of DO was 7.28 mg/l (Fig. 2). The highest value 7.43 mg/l was found at point-5 and the lowest value 7.17 mg/l was found at point-4. DO values of all sampling points were higher than the standard value (4-6 mg/l) given by WHO, 1993 because of the presence of a large amount of metallic wastes and decreasing decomposition activities by a microorganism.

BOD

Biological oxygen demand (BOD) is a chemical process for the ascertaining of DO required by aerobic organisms in a water body to break disintegrate organic material present in a given water sample at a certain temperature over an earmarked period time (Sawyer, 2003). In present study the average value of BOD was 1.90 mg/l (Fig.3). The highest value was 2.77 mg/l found at point-1 and lowest value was 1.4 mg/l found at point-4 and 5. All BOD values were within the average water quality standard (5 mg/l) given by WHO, 1993 (WHO, 1993) for surface water due to increasing inorganic wastes and metallic wastes day by day in the ship breaking area.

pH

pH is the negative logarithm of the hydrogen ion concentration of a solution and it is thus a measure of whether the liquid is acid or alkaline. The pH scale ranged from 0 (very acidic) to 14 (very alkaline). In the present study the average value of pH was 8.03 (Fig.4). The highest value was 8.04 found at point-1 and lowest value was 8.02 found at point-5. In the study pH values were within the WHO (1993) standard value (6 - 8.5). In this study pH increased due to photosynthetic activity is reduced. Due to shipbreaking activities photosynthetic activities was reduced and had a serious impact on aquatic organism lifecycle (Patil *et al,* 2012).

EC

Electrical Conductivity is the amount of electric current and total sum of dissolved ions in water body Hud et al, 2005). In present study average value of EC was 6391.20 µS/cm (Fig. 5). The highest value was 6745 µS/cm found at point-4 and lowest value was 5752 µS/cm found at point-1. All the values were higher than the permissible limit for surface water (3000 µS/cm) given by WHO (1993). EC positively correlated with transparency, salinity, TDS; negatively correlated with air temperature, DO, BOD and water temperature (Talukder *et al*., 2016). When EC increased in water in a shipbreaking yard , the water was very hard and cause different health hazard.

Temperature

Water temperature plays a significant role in affecting physical, chemical, and biological processes in water bodies. Increasing water temperature solubility rate of gases in water

decreased the respiration rate of aquatic organisms as a result consumption of oxygen increases the rate of decomposition (Chapman and WHO, 1996). In the present study average value of temperature was 27.1 °C (Fig. 6). The highest value was 27.6°C found at point-1 and lowest value was 26.8°C found at point-5. All temperature values of the present study (DoE, 2001) were within the DoE (2001) standard value (30.5 °C).
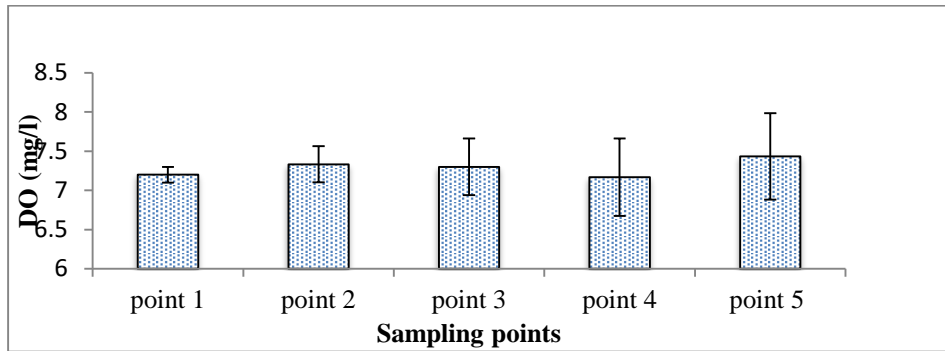
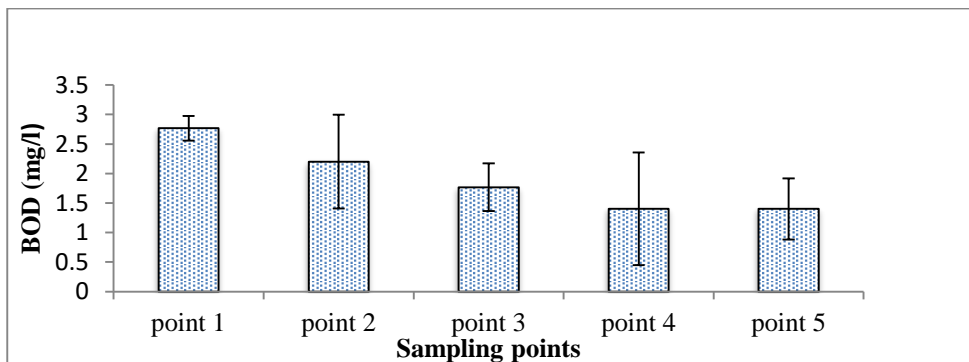Figure 2: Values of DO at different sampling points.

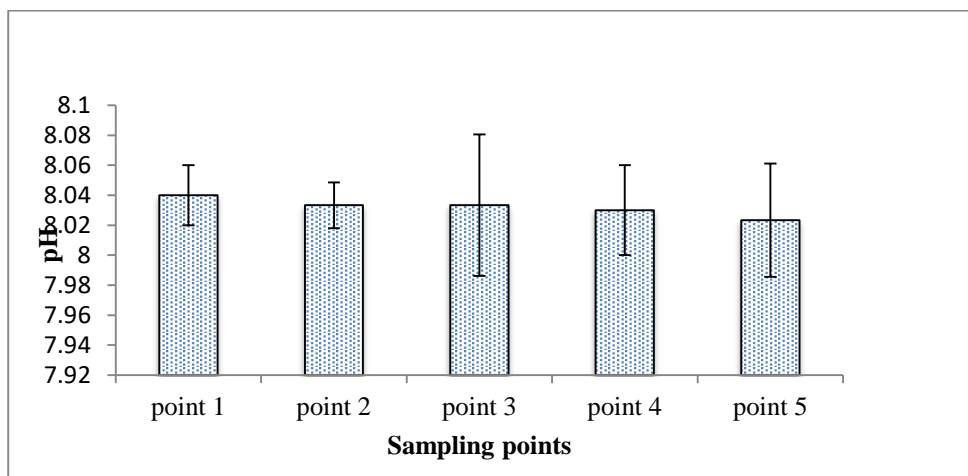Figure 3. Values of BOD at different sampling points

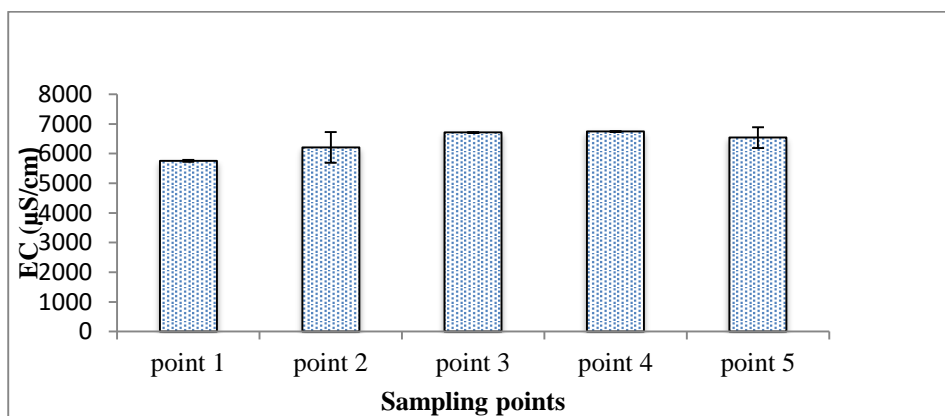Figure 4. Values of pH at different sampling points

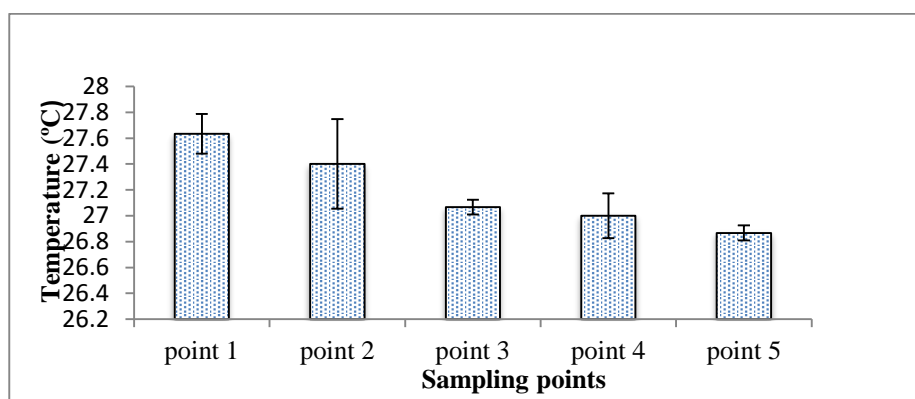Figure 5. Values of EC at different sampling points

Figure 6. Values of Temperature at different sampling points

TDS

TDS is the very significant chemical parameter of water. TDS mainly indicate the presence of various kinds of minerals like ammonia, nitrite, nitrate, phosphate, alkalis, some acids, sulfates and metallic ions etc. which are comprised both colloidal and dissolved solids in water (Rahman et al, 2012). The enhanced TDS could indicate the presence of salts due to wastes (Irshad et al, 2011). The TDS value of the samples collected from all points were higher than the machine's (HM digital) detection limit, i.e. 10,000 mg/l which exceeds the standard value (500 mg/l) given by EPA (EPA, 2001) and WHO (WHO, 1993). In ship breaking areas various refuse and disposable materials are discharged and spilled from scraped ships and often get mixed with the water and higher TDS value shows deterioration of the physiochemical properties of seawater within the ship breaking area (Hossain *et al.*, 2006).

Heavy Metals

Different heavy metals discharge during shipbreaking activities. In the present study, the order of concentration of heavy metals was found Fe>Cd>Pb>Cu>Hg in the water. The observed Cu values in all water samples were less than the water quality standard 1 mg/l (WHO) for surface water. According to the study, Fe concentration ranged from 25.2 to 53.6 mg/l and highest value was found at point-4 and lowest value was found at point-1 (Table 1). Cd concentration ranged from 0.003 to 0.007 mg/l (Table 1). The highest value of Cd was found at point-3 and lowest value was found at point-1, point-2, point-4 and point-5. Pb concentration at all sampling points were 0.001 mg/l (Table 1). Cu concentration at all

sampling points was < 0.1 mg/l and Hg concentration was <0.001 mg/l at all sampling points (Table 1).

Table 1. Heavy metal concentrations of water samples in ship breaking site, Kumira Ghat, Sitakunda.

	SI No.	Heavy Metal Concentrations (mg/l)				
		Pb	Cd	Fe	Hg	Cu
	Point-1	0.01	0.003	25.2	<0.001	<0.1
	Point-2	0.01	0.003	30.3	<0.001	<0.1
Sampling Points	Point-3	0.01	0.007	44.4	<0.001	<0.1
	Point-4	0.01	0.003	53.6	<0.001	<0.1
	Point-5	0.01	0.003	53.4	<0.001	<0.1
Permissible limit for surface water (WHO, 1993; EPA, 2001)		0.05	0.005	0.1-1	0.002	1

Correlation

Pearson's correlation analysis was done among the water quality parameters. Positive correlations were found among pH and Temperature; BOD and Temperature; BOD and pH; and Fe and EC. **Also** negative correlations were found among EC and Temperature; EC and BOD; Fe and Temperature; and Fe and BOD (Table3).

Table 3. Correlations among water quality parameters.

Parameter	Temperature	DO	pH	BOD	EC	Fe
Temperature	1					
DO	-.411	1				
pH	.896[*]	-.652	1			
BOD	.981[**]	-.308	.881[*]	1		
EC	-.911[*]	.176	-.689	-.932[*]	1	
Fe	-.974[**]	.221	-.839	-.977[**]	.893[*]	1

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

CONCLUSION

The surface water quality of ship breaking area in Kumira Ghat, Sitakunda, Bangladesh is not satisfactory compared to the typical coastal areas where there is no ship breaking yards. The EC and TDS were much higher than the standard level indicating high pollution of water. The concentration of Fe exceeded the standard level. Finally, it could be said that, if the ship breaking industry is to spread in the country it could damage the water quality of the coastal area of Bangladesh. So it is needed to ensure the minimization of pollution through effective measures against environmental and health hazards inherent in the process of ship breaking. Future research work could be done to find out the effects of ship breaking yards on air, health and marine animals.

REFERENCES

APHA, Standard Methods for the Examination of Water and Wastewater. (22ⁿᵈ Edition). (1998). Published by American Public Health Association (APHA). American Water Works Association, Water Environment Federation.

Chapman, D. V. (Ed.). (1996). *Water Quality Assessments: A Guide to The Use of Biota, Sediments and Water in Environmental Monitoring*. CRC Press.

Chang, Y. C., Wang, N., & Durak, O. S. (2010). Ship Recycling and Marine Pollution. *Marine pollution bulletin*, *60*(9), 1390-1396.

DoE (Department of Environment). (2001). The General Overview of Pollution Status of Rivers of Bangladesh. Bangladesh: Department of Environment.

EPA (Environmental Protection Agency), U.S. (2001). Drinking water criteria document for silver, Environmental criteria and assessment office, Cincinnatia, OH. ECA-CIN-026, 86-88.

Hasan, A. B., Kabir, S., Reza, A. S., Zaman, M. N., 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. *Journal of Geochemical Exploration*, *125*, 130-137.

Hossain, M. S., Chowdhury, S. R., Jabbar, S. A., Saifullah, S. M., & Rahman, M. A. (2008). Occupational Health Hazards of Ship Scrapping Workers at Chittagong Coastal Zone, Bangladesh. *Chiang Mai J. Sci*, *35*(2), 370-381.

Hossain, M. M. M., & Islam, M. M. (2006). *Ship Breaking Activities and its Impact on The Coastal Zone of Chittagong, Bangladesh: Towards Sustainable Management*. Chittagong, Bangladesh: Advocacy & Publication Unit, Young Power in Social Action (YPSA).

Huq, S. I., & Alam, M. D. (2005). A Handbook on Analyses of Soil, Plant, and Water. BACER-DU. *University of Dhaka, Bangladesh*, *22*, 246.

Irshad, M., Faridullah, A., Malik, N., & Khan, T. (2011). Effect of Solid Waste on Heavy Metal Composition of Soil and Water at Nathiagali-Abbottabad. *Journal of the Chemical Society of Pakistan*, *33*(6), 830-834.

Kane, S., Qarri, F., Lazo, P., & Bekteshi, L. (2010). The Effect of Physico-Chemical Parameters and Nutrients on Fish Growth in Narta Lagoon, Albania. *J Hygienic Engin Design UDC*, *639*(496.5), 62-68.

Kutub, M. J. R., Falgunee, N., Nawfee, S. M., & Rabby, Y. W. (2017). Ship Breaking Industries and Their Impacts on The Local People and Environment of Coastal Areas of Bangladesh. *Human and Social Studies*, *6*(2), 35-58.

Muhibbullah, M. (2013). Health Hazards and Risks Vulnerability of Ship Breaking Workers: A Case Study on Sitakunda Ship Breaking Industrial Area of Bangladesh. *Journal of Geography and Regional Planning*, *2*(8), 172-184.

Occupational Safety and Health Administration (OSHA). (2001). *Ship Breaking Fact Sheet*. US Department of Labor, OSHA.

Patil, P. N., Sawant, D. V., & Deshmukh, R. N. (2012). Physico-Chemical Parameters for Testing ff Water–A Review. *International journal of environmental sciences*, *3*(3), 1194-1207.

Rahman, A. L., Islam, M., Hossain, M. Z., & Ahsan, M. A. (2012). Study of The Seasonal Variations in Turag River Water Quality Parameters. *African Journal of Pure and Applied Chemistry*, *6*(10), 144-148.

Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2003). *Chemistry for Environmental Engineering and Science* (Vol. 5, p. 587590). New York: McGraw-Hill.

SHED (Society for Environment and Human Development). (2002). *Bangladesh Environment: Facing the 21ˢᵗ Century*, 340.

Talukder, A., Mallick, D., Hasin, T., Anka, I. Z., & Hasan, M. M. (2016). Spatio-Temporal Variability in Hydro-Chemical Characteristics of Coastal Waters of Salimpur, Chittagong Along The Bay of Bengal. *Journal of Fisheries*, *4*(1), 335-344.

Wei, Y., Zhang, J., Zhang, D., Tu, T., & Luo, L. (2014). Metal Concentrations in Various Fish Organs of Different Fish Species from Poyang Lake, China. *Ecotoxicology and environmental safety*, *104*, 182-188.

World Health Organization. (1993). *Guidelines for Drinking Water Quality, 2nd Edition*. Vol-1, pp. 14-22, 173.

YPSA. (2005). *Workers in Ship Breaking Industries: A Base Line Survey of Chittagong, Bangladesh*. Young Power in Social Action (YPSA). Chittagong. pp 79.