The physicochemical assessment study was carried out to assess the soil quality in Ship-breaking yards of Chittagong region, Bangladesh. In order to study the different physicochemical parameters, soil samples from thirty Ship-breaking yards were collected and analyzed during the period 2011-2012. Collected soil samples were analyzed for the following parameters: pH, EC, soil salinity, nitrogen, potassium, chloride, phosphate, nitrate, nitrite, cadmium, chromium, arsenic, cobalt, copper, iron, lead, manganese, nickel, silver and zinc using the procedure outlined in the standard methods. The laboratory findings were compared with the recommended values set by the control area and standard calculated on the World Scale. The ranges of different physicochemical parameters obtained are as follows: pH: 4.17-6.92, EC: 1722-5600 µS cm⁻¹, soil salinity: 16651.7-54152, N: 115-1205 mg kg⁻¹, K: 693.75-812.45 mg kg⁻¹, chloride: 1900-7500 mg kg⁻¹, phosphate: 8.36-34.84 mg kg⁻¹, nitrite: 0.03-8.41 mg kg⁻¹, nitrate: 0-74.05 mg kg⁻¹, iron: 1250-10057 mg kg⁻¹, manganese: 0-158.90 mg kg⁻¹, chromium: 0.6-65.2 mg kg⁻¹, cobalt: 5.75-24.45 mg kg⁻¹, nickel: 16.30-162.2 mg kg⁻¹, copper: 0-295.65 mg kg⁻¹, zinc: 33.25-305.10 mg kg⁻¹, silver: 4.60-132.45 mg kg⁻¹, cadmium: 0.55-3.95 mg kg⁻¹, lead: 0-137.05 mg kg⁻¹, arsenic: 0.0152-0.9505 mg kg⁻¹. Soil nutrients like N, K were found in the level below that of the control area and standard calculated on the World Scale. Trace and heavy metals like Ag, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn were found very much higher than the control area and standard values set by World Scale. The anion like nitrate, nitrite, phosphate for which no standard values are recommended by World Scale are also not in good conditions and the concentration of chloride was very higher than the control area and the standard. From Pearson Correlation program, significant positive and negative correlations were found for different parameters. These assessment data indicated that the soil of Ship-breaking yards in Chittagong region are highly polluted which are continuously polluting the Coastal Zone, sea and the rivers of Chittagong, especially the water of Karnafuli River is being polluted greatly. The polluted water of the Karnafuli River may affect the biodiversity of the Halda River. Results from this study show that discharges from the broken Ships are highly toxic in nature. This affects not only the soil, aquatic environment and human beings of the surroundings but also poses a serious threat to ground and surface water resources of the adjoining areas and coastal zone of Chittagong, Bangladesh.

INTRODUCTION

Ship-Breaking industry is one of the most important and rapidly developing industrial sectors in Bangladesh. It has a high importance in terms of its environmental impact, since it produces considerably large amounts of POP'S, PCBS, PAHs, Dioxins, PVC, organotins, asbestos, heavy metals, oil and oily substances. A major environmental problem in Ship-breaking industries is the discharge of these pollutants to the environment, causing pollution of nearby soil and water in the coastal zone of Chittagong.

Bangladesh is a small and densely populated country with an area of about 1, 47, 570 square kilometres. It has a long coastal belt of about 710 km which is enriched with natural resources specially fish and other aquatic species of different varieties and has been the focal point of different economic activities. Most of these seashore are situated in Chittagong. Sitakundo is a seashore area situated a few kilometres north of Chittagong where most of the ship-breaking yards are concentrated. Ship-breaking industry has not been developed in a day. It has been developed gradually in Bangladesh passing through various stages of its development at an international level. Though the Ship-breaking in Bangladesh started in sixties, commercially it started in late seventies. The only Ship-breaking industry of the country has been developed in Sitakundo areas, Chittagong. There are about 20 forward and backward linkage industries based on this ship-breaking. Now, there are about 84 ship-breaking yards in Sitakundo.

At present, the positron of Bangladesh is third in the world for ship-breaking. The largest ships of the world are cut in the ship yard of Bangladesh. This industry pays about 700 crore taka each year to the government of Bangladesh. Bangladesh needs eight million tons of building materials per year, in which most needed material is iron and Ship-breaking industry is supplying 90% iron materials to the country. During the liberation War in 1971, a Pakistani ship "Al Abbas" was damaged by bombing. Later on this was salvaged by a Soviet salvation team from Chittagong port and bought to the Fauzdarhat seashore. In 1974 the Karnafuli Metal Works Ltd bought this as scrap, which is considered as introduction of commercial Ship-breaking in Bangladesh.
Following these tentative beginnings, the ship-breaking sector experienced a boom in the 1980s. As developed countries like United Kingdom, Spain, Scandinavian countries, Brazil, Taiwan, and South Korea wanted to get rid of an industry, which was not in compliance with the new environmental protection standards, Bangladeshi industrialists took the opportunities allured by huge profit.

Environment is not static, rather dynamic, complex system reflection interdependence of living things and their relationships with land, air and water.3

Soil is one of the main components of environment. It is a natural body occupying a portion of earth that supports plant growth, which has possessed properties due to the action of climate and vegetation upon parent material as conditioned by relief over a period of time.4 In industrial area pollutants acid rain decreases nutrients from soil affect soil. Nitrogen availability decreases soil respiration and increases nutrient leaching from the soil. The effects of soil contamination with heavy metals that is toxic to plants in the industrial area.5

Heavy metals is a loose term for a wide group of metals of atomic density >6 g/cm³, which are generally associated with pollution and toxicity.6 Metals and metal compounds are natural constituents of all ecosystems, moving between atmosphere, hydrosphere, lithosphere, and biosphere.7 Heavy metals are stable and persistent environmental contaminants of aquatic environments. Some metals like Zn, Cu, Fe and Mn, which are required for metabolic activity in organisms, lie in the narrow "window" between their essentiality and toxicity. Other heavy metals like Cd, Ag, Co, Hg, Cr and Pb, may exhibit extreme toxicity even at low levels under certain conditions, thus necessitating regular monitoring of sensitive aquatic environments.8 Their distribution in the environment is a result of natural processes (volcanoes, erosion, spring water, bacterial activity) and anthropogenic activities (fossil fuel combustion, industrial and agricultural processes). While, compounds containing Cd, Cu, Cr, Hg, Ni, Pb, and Zn are industrially produced, metallic derivatives containing Cu, Co, As, Sb, Zn, Cd, Au, Cr and Pb, are also used in home activities.9 Therefore, metal compounds are also increasingly introduced in the environment and could finally accumulate in biotic systems.10 Metals are introduced into the coastal zone environment by the anthropogenic activities and are absorbed / incorporated into the sediments.

Heavy metals are not removed from water and soil by self-purification.11 A major part of the metals accumulate in the estuarine and the continental shelf regions which are the important sinks for the land derived activities.12 Geochemical cycle of trace metals in the coastal zone environment is an important process to determine the present level of metal enrichment which has been deposited via a number of ways through rivers, other industrial and domestic effluent inputs. The elevation of metal levels often results in a high concentration in the bottom sediment. As a result, sediments become "chemical archives" of heavy metal accumulations, which can provide valuable information in resolving the source and sink of heavy metal pollution.13

In the coastal areas, metals are remobilized, released or accumulated in different forms due to the wide variations in physicochemical parameters, high sedimentation rates and influence of wave motion, variable redox conditions and organic matter contents.14 The concentrations of heavy metals in aquatic environment and marine organisms have been of considerable interest because of their toxic effects which are important in human beings.15

EXPERIMENTAL

Selection of study area

The study was conducted in the different zones of Chittagong viz. Fauzdarhat, Bhatiary, Kumera, Potenga etc. For the selection of industries preliminary, a reconnaissance survey was conducted to know the names, locations & apparent status of various Ship-breaking industries in Chittagong. From the reconnaissance survey Thirty (30) important Ship-breaking industries were selected randomly for the current study.
Assessment of soil pollutants due to ship breakings in the coastal zone

Sample Collection

Samples are collected for various examinations under different conditions. An ideal sample should be one which is both valid and representative i.e., the sample must represent the conditions that exist at the sampling point. A survey work was conducted for the identification of sampling spots and the current soil quality conditions for a large part of the Ship-breaking area of Chittagong. Statistical methods of sampling have been used for collecting samples. Multiple samples were collected from same spot for continues monitoring. The samples were also collected in different seasons to study the seasonal variation of the results during the hydrological year 2011-2012. Samples were collected in sample bags or medium zip-lock bags. The bags were then labelled by mentioning the name and location of the sample site, date and time of collection. The dried soil samples were then passed through a 2 mm diameter and 325 mesh sieves. The fine soil samples were stored and preserved using suitable preserving agents and techniques for different parameters. Soil samples were dried in the air under room temperature after removing the roots and stones, and then crushed and homogenized with a wooden pestle in a wooden mortar. Collected samples were shifted to the laboratory as soon as possible for the analysis of various physicochemical parameters.

Experimental Methods

pH, EC, salinity, nitrate, nitrite, chloride, phosphate were measured immediately after extraction of soil at the laboratory. For the analysis of trace metals by UV/Visible spectrophotometry and atomic absorption spectrophotometry (AAS) samples were digested according to wet-digestion method. For chemical analysis, standard preservation techniques and methods of analysis (APHA, 1992; Chattopadhyay, 1998; Manivasakam, 2000; De, 2000) were used.

Combined Meter, Model–HI 255, HANNA, Combined meter has been used for the determination of pH, Electrical Conductance and soil salinity. Nitrogen was measured by Kjeldhal Distillation Method. Nitrite-N was determined by calorimetric method by formation of a reddish purple azo dye produced at pH 2.0 to 2.5 by coupling diazotized sulfanilamide with N-(1-naphthyl)ethylenediamine (NED dihydrochloride). Chloride was determined by argentometric method in a neutral or slightly alkaline solution using potassium chromate as indicator by standard silver nitrate as titer. Phosphate was determined by calorimetric vanadomolybdophosphoric acid method after extraction of soil with Bray and Kurtz no. 2 extractant. Iron was determined by calorimetric method using 1, 10-phenanthyline as chelating agent. Manganese was determined by calorimetric per-sulfate oxidation method. In colorimetric methods a Shimadzu, Model-1800 UV-Vis spectrophotometer was used. Arsenic was determined by silver-dietyldithiocarbamate method. Cadmium, chromium, copper, cobalt, nickel, silver, lead, zinc was determined by Varian Model-AA240FS fast sequential atomic absorption spectrophotometer.

Table 1. Average values of soil quality parameters of different Ship-breaking industries in Chittagong region

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Study area value, mg kg⁻¹</th>
<th>Average value of soil quality parameters</th>
<th>Standard value for sandy soil, mg kg⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>4.17 ± 0.01</td>
<td>6.57 ± 0.01</td>
<td>4.0–4.5</td>
</tr>
<tr>
<td>EC, µS cm⁻¹</td>
<td>1722 ± 0.01</td>
<td>3595.3 ± 0.01</td>
<td>1120</td>
</tr>
<tr>
<td>Soil salinity, µS cm⁻¹</td>
<td>16651.7 ± 0.01</td>
<td>34766.55 ± 0.01</td>
<td>10830.4</td>
</tr>
<tr>
<td>N, mg kg⁻¹</td>
<td>115 ± 0.01</td>
<td>720.59 ± 0.01</td>
<td>10000</td>
</tr>
<tr>
<td>K, mg kg⁻¹</td>
<td>693.75 ± 0.97</td>
<td>712.77 ± 0.97</td>
<td>100</td>
</tr>
<tr>
<td>Cl⁻, mg kg⁻¹</td>
<td>1900 ± 0.01</td>
<td>8.34 ± 0.64</td>
<td>17.30</td>
</tr>
<tr>
<td>PO₄³⁻, mg kg⁻¹</td>
<td>0.03 ± 0.01</td>
<td>3.48 ± 0.31</td>
<td>1.39</td>
</tr>
<tr>
<td>NO₂⁻, mg kg⁻¹</td>
<td>BDL</td>
<td>9.25 ± 0.15</td>
<td>-</td>
</tr>
<tr>
<td>NO₃⁻, mg kg⁻¹</td>
<td>BDL</td>
<td>24.33 ± 0.49</td>
<td>up to 0.4</td>
</tr>
<tr>
<td>Ag, mg kg⁻¹</td>
<td>4.60 ± 0.07</td>
<td>0.755 ± 0.01</td>
<td>6.34</td>
</tr>
<tr>
<td>As, mg kg⁻¹</td>
<td>4.01 ± 0.01</td>
<td>0.956 ± 0.001</td>
<td>0.05</td>
</tr>
<tr>
<td>Cd, mg kg⁻¹</td>
<td>0.55 ± 0.01</td>
<td>3.95 ± 0.01</td>
<td>0.37</td>
</tr>
<tr>
<td>Co, mg kg⁻¹</td>
<td>5.75 ± 0.01</td>
<td>24.45 ± 0.08</td>
<td>11.72</td>
</tr>
<tr>
<td>Cr, mg kg⁻¹</td>
<td>0.6 ± 0.00</td>
<td>65.2 ± 0.61</td>
<td>16.67</td>
</tr>
<tr>
<td>Cu, mg kg⁻¹</td>
<td>BDL</td>
<td>295.65 ± 0.15</td>
<td>101.24</td>
</tr>
<tr>
<td>Fe, mg kg⁻¹</td>
<td>1250 ± 0.10</td>
<td>10057 ± 0.15</td>
<td>600.67</td>
</tr>
<tr>
<td>Mn, mg kg⁻¹</td>
<td>BDL</td>
<td>158.90 ± 0.91</td>
<td>58.69</td>
</tr>
<tr>
<td>Ni, mg kg⁻¹</td>
<td>16.30 ± 0.15</td>
<td>162.2 ± 0.01</td>
<td>41.72</td>
</tr>
<tr>
<td>Pb, mg kg⁻¹</td>
<td>BDL</td>
<td>137.05 ± 0.15</td>
<td>36.27</td>
</tr>
<tr>
<td>Zn, mg kg⁻¹</td>
<td>33.25 ± 0.47</td>
<td>305.10 ± 0.51</td>
<td>149.50</td>
</tr>
</tbody>
</table>

Figure 3. Map showing the sampling points at study area
RESULTS AND DISCUSSION

The results of different physicochemical parameters of coastal soil of Ship-breaking area of Chittagong region with Standard calculated on the World Scale are shown in Table 1.

For the soil of Ship-breaking industries in Chittagong region the pH is slightly acidic from 4.17 to 6.92 (Table 1). It was seen that the soil had pH value higher than that of the standard value (4.0-4.50), indicating that the soil is slightly acidic. The pH of soil was positively correlated with cobalt (Co) and negatively correlated with phosphate (PO₄³⁻) (Table 2). The EC of the soil was found to vary from 1722 µS cm⁻¹ to 5600 µS cm⁻¹ (Table 1) but the standard value of EC for sandy soil is 1120 µS cm⁻¹. It was shown that the EC value of soil of all the yards was very much higher than that of standard (1120 µS cm⁻¹). The EC of soil was found to be positively correlated with soil salinity, chloride (Cl⁻) and negatively correlated with lead (Pb) content (Table 2).

The soil salinity was found to vary from 16651.7 µS cm⁻¹ to 54152 µS cm⁻¹, indicated that approximately all of the soil of ship breaking area had salinity values higher than that of control area (22482.7 µS cm⁻¹). Again the standard value of soil salinity for sandy soil is 10830.4 µScm⁻¹, shown that the salinity value of soil of all the yards was higher than that of the standard (10830.4 µS cm⁻¹). The soil salinity of soil was found to be positively correlated with EC, chloride (Cl⁻) and negatively correlated with lead (Pb) content (Table 2).

The mean values of soil nutrients like N, K were found 882.93 mg kg⁻¹ and 720.59 mg kg⁻¹ respectively but standard value of N, K are 14000 mg kg⁻¹ and 10000 mg kg⁻¹ respectively. It was found that values of N, K of all the yards had lower than that of standard value (14000 mg kg⁻¹ and 10000 mg kg⁻¹). It was found that Nitrogen content of soil is positively correlated with lead (Pb), zinc (Zn), cadmium (Cd) and negatively correlated with nitrite (NO₂⁻). The chloride (Cl⁻) content varied from 1900 mg kg⁻¹ to 7500 mg kg⁻¹, again the concentration of chloride required for healthy growth of plant is 100 mg kg⁻¹, showed that value of chloride in soil of all the yards had very much higher than that of standard value. Chloride in soil was found to be positively correlated with EC and soil salinity (Table 2).

So it can be concluded that the studied physicochemical parameters such as pH, EC, soil salinity of the soil in ship yards of Chittagong region was found to be higher than the control area and standard value calculated on the World Scale. Soil nutrients such as N, K of all Ship-breaking yards of Chittagong region were found to be lower than the control area and standard value calculated on the World Scale. Soil anions such as NO₂⁻, NO₃⁻ etc. were found to be higher than the values set by the control area, which indicates that the soil is not in good conditions. Again Cl⁻ and PO₄³⁻ were found to be lower than the values set by the control area.

Trace and heavy metals namely Fe, Mn, Co, Cr, Ni, Cu, Ag, As, Cd, Zn and Pb in most of the ship-breaking yards were present in higher amount than the standard value calculated on the World Scale and than the control area. The above data indicate that the ship-breaking yards in Chittagong region are highly polluted though concentration...
of some anions and some metals of some yards were found within the range of control area and standard values. Therefore these pollutants, when discharged, are polluting the nearby soil and water thus greatly rendering us a highly polluted environment.

RECOMMENDATIONS

Considering the positive role of Ship-breaking in national economy Ship-breaking can not be stopped. Following steps may be taken for sustainable practice of Ship-breaking activities in Chittagong Coastal area of Chittagong:

Government should formulate and implement a national policy and principles for safe and sustainable Ship-breaking after having consultation with relevant organizations, employers and workers.

Government should include this sector under the ministry of industry defined by the Factory Act, 1965 and formulate a policy so that, worker’s rights and welfare; occupational safety & health (OHP) could be ensured and it could be eco-friendly as well.

As Fauzdarhat has been earmarked for recreational facilities in the Master Plan of Chittagong, the Master Plan is to be revised till a final study is made by the experts on the impact of Ship-breaking being developed in its present site.

a) A gas free certificate (in true sense) must be obtained before any ship is broken. Oil must be removed and the oil tanks must be thoroughly cleaned either chemically or manually and the ship breakers must obtain a tank clearance certificate from the Mercantile Marine Department before beaching.

b) A systematic and periodic inspection of the whole yard should be done before a certificate of compliance is issued by the Department of Environment (DoE) & Department of Shipping for control of pollution during Ship-breaking.

The sea shall be kept undisturbed as far as practicable for healthy growth of marine biodiversity and human health. Because, many of the ship-breaking components are highly toxic, persistent and carcinogenic in nature and they prove fatal for aquatic food chain & human health. Therefore,

a) Short and long term scientific study should be immediately started to assess the impacts of Ship-breaking activities on coastal water, soil and fishery resources, as well as human health.

b) To mitigate the problems and environmental impacts, cooperation & collaboration among scientists, policy makers, owners, local representatives, NGO’s, media and different stakeholders must be achieved through consultation, seminars, discussions etc.

No Ship-breaking licenses should be issued to any one unless he produce requisite permission showing that necessary lease of land had already been taken for the purpose.

Fire stations and hospitals should be set up near to the yards, for the welfare of the workers and avoiding severe loss by any accident.

The authority should select a “certain isolated and protected scrapper’s yard” for dismantling the ships instead of the seashore areas.

The Ship-breaking activities should be carried out in a planned and hygienic way. A layout should be designed before starting to break the ship.

For sustainable Ship-breaking policy and its implementation, linkage with international organizations and NGOs; interagency cooperation, strengthening capacity building of the relevant government department through training is must.

Ship breakers or owners should provide PPE (personal protective equipment) in general and appropriate PPE in specialized cases for workers and labours.

IMO, ILO & Basel convention guidelines are not yet mandatory. So, for sustainable practices these guidelines should be translated into laws and procedures pertaining to the sustainable Ship-breaking activities in Bangladesh.

Awareness of people about the risks, effects and remedies of pollution should be increased so that they can play important role in the abatement of pollution due to Ship-breaking activities.

Assessment data will be published in national magazine, newspaper and international journals so that public awareness will be increased.

Assessment data will be provided to the proper Govt., Authority and NGO’s for taking proper action and making new national and regional policies and appropriate preventive measures against the pollution due to Ship-breaking activities in this region.

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