IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 11, Issue 8 Ver. II (August. 2017), PP 44-49
www.iosrjournals.org

Investigation onto Soil Salinity of Hazaribagh Tanning Industrial Area, Dhaka, Bangladesh

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Abstract: *The physico-chemical properties of soils of Hazaribagh (Dhaka) Tanning industrial area were studied. The aim of this study was to investigate the pH, electrical conductivity and the concentrations of some soluble salts of soils near existing buildings and also soils inside of tanneries as the tanneries are relocating from this area and where future construction project will start for further development. The soil samples from eight different places along with a building sample were collected and the physico-chemical properties and amounts of some salt ions like Na^+, Cl^- and SO_4^{2-} were determined. It was found that soil salinity inside and very close to the tanneries was in high to very high saline range and soils far from tanneries were in slightly saline range. This information will help builders to know the nature of soil and the amount of soluble salts present in this industrial area and their impacts on building materials.*
Keywords: *pH, EC, Soil salinity, Hazaribagh*

Date of Submission: 31-07-2017 Date of acceptance: 05-09-2017

I. Introduction:

The soil is the natural foundation that supports all structures and where buildings, roads, bridges, dams are made and life is based on. But the salinity of soil is a professed worsening problem and also responsible for extensible damage to the public and private infrastructure. A research claimed that salinity damaged cost to infrastructure at the areas of Murray-Darling Basin, Australia was at around $206 million per annum (Wilson, 2003). Soil salinity is categorized primarily or natural occurring and secondarily or human induced (Allbed and Kumar, 2013). Salinity due to leather industry is secondary salinity. Leather industry is well-known due to generating excessive solid, liquid and gaseous pollutants. During the present study around 249 tanneries were located in Hazaribagh area, at the western part of Dhaka city (Huq, 1998) and where no individual or central effluent treatment had been established. Currently, all the tanneries are shut down and shifting to a new place at Savar. By the way, liquid wastes discharged from tanneries carried out by city corporation drainage system and deposited to the low land, road side during over flood. Inorganic ions of Na^+, Mg^{2+}, Ca^{2+}, K^+, Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-} are dissolved in soils as soluble salts and when their amount are in high level, soils are considered saline.

Since a huge amount of salts and other chemicals were used in beam house operation in tanning process and a large amount of liquid waste was drain every day which went to nearby river and low land during over floated and in the rainy season whole area's roads and land became under water with the liquid waste of tannery due to blockage in drainage system. This waste liquor frequently overflowed to the nearby area and water evaporates but the salt ion remains in the surface. As this process was repeated for a long time from the establishment of tannery, so there is a huge possibility of salt accumulation in this area. Due to capillary action this soil moisture rise up through the building wall and salts start react with building materials and concrete. Salinity damage in the building or infrastructure is caused by combination impacts of salt and water and the rate of damage depends on water management, climate, building age and building materials. Corrosion of metals, physical breakdown of brick and mortar, flaking off plaster on internal and external walls and paints, fungal growth on bearers and joints are caused for the upward movement of saline water from the building foundation and is influenced by the permeability of the brickwork and amount of evaporation loss of moisture from the drying surface (McGhie, 2007). The aim of this study was to make a good idea of salinity level in Hazaribagh tanning industrial area by determining soils salinity level and thus observing the result, it will be helpful for construction industry to take necessary steps about salinity damage to the buildings and infrastructure.

II. Materials and Methods

Study Area: The study was conducted at Hazaribagh tanning industrial area. The location of tanning industrial area is shown in Fig. 1 according to the map. Most of the surroundings are covered with tanneries, houses and schools.

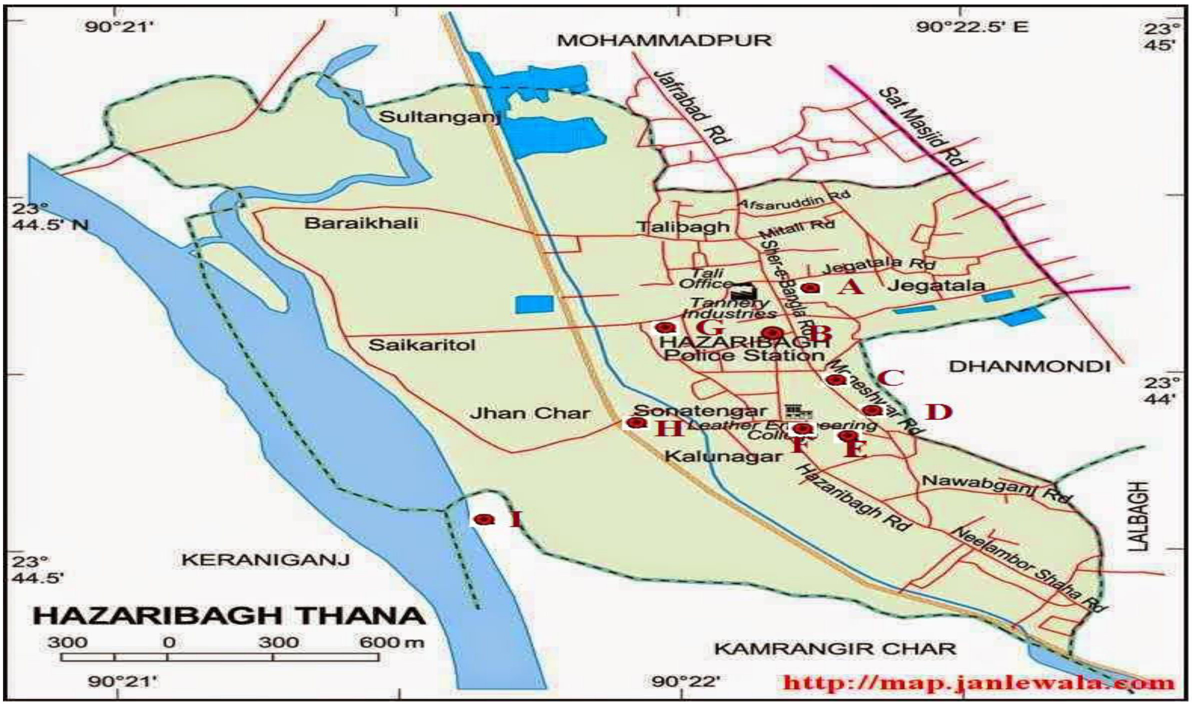

Fig. 1 Location of study area

A- Chinese tannery, **B**- K2 tannery, **C**- MI tannery, **D**- Jeans Dying Ltd., **E**- Shahjalal tannery, **F-** Reliance tannery, **G**- Gajh Mahal School field, **H**- Baribadh- Kalunagar and **I**- Kamrangir Chor, Bank of Buriganga river.

The purpose of the present study was to evaluate the extent of soil salinity in certain selected places and those were selected based on tannery area, the area beside the tannery and at the bank of Buriganga River. Eight points in the study area were selected for sample collection. Three samples were collected from each point at the different depth like 10, 30 and 90 cm below of the soil surface from Chinese tannery, K2 tannery, MI tannery, Jeans Dying Ltd., Shahjala tannery, Baribadh Kalunagor, Gajh Mahal School field (near to Hazaribagh tannery area) and Kamrangichor (Bank of Buriganga River) respectively. One sample was collected from the wall of Reliance tannery building. All the samples were collected in plastic pots and after removing extra materials from soil, dried at room temperature and sieved. In laboratory these samples were analyzed for different chemical parameters following standard methods.

2.1 Determination of pH

Freshly collected samples were taken for determining the pH. The ratio of the distilled water to the soil sample was 5:1. The pH of soil was measured using digital pH meter.

2.2 Determination of sodium ion in sample

A 0.5 g of each sample was digested with concentrated 10 mL HCl in an electric microwave machine (Model: PFP-7 JENWAY). Filtration was done with Whitman no. 42 filter paper and diluted to 25 mL with double distilled water. Then the sodium ion was determined by flame photometer (PFP7, JENWAY).

2.3 Determination of sulphate ion

A 10 g of each soil sample was taken in 50 mL conical flask and 40 mL of de-ionized water was added. All the flasks were placed in shaking machine for half an hour and after shaking the filtration were done. Turbidity was developed by the method of Hunt (1980) and measured by using spectrophotometer (Model:Hach, DR 5000).

2.4 Determination of chloride content

Chloride was extracted from the sample using distilled water and the ratio of sample and water was 1:5. After stirring the mixture with glass rod the solution was filtrated by using Whatman no. 42 filter paper. Charcoal treatment was done in the case of some extract. Then the chloride content was determined by titration process using silver nitrate solution.

2.5 Measurement of electrical conductivity

Electrical conductivity 1:5 **-** Electrical conductivity of the soil was determined by extraction process using the electrical conductivity machine (CON 700). 5 g of sample and 25 mL of distilled water were taken in a test tube and the solution was stirred with a glass rode for 30 min. Then the result was taken after standardizing the EC machine.

All chemicals used in soil analysis were Analytical grade.

III. Results and Discussion

Soils are classified into four categories acidic, normal, alkaline and alkali according to canola encyclopedia and other laboratory standards (Jackson, 1967). Electrical conductivity standards which are classified as non-saline, slightly saline, moderately saline and very severely saline (Jackson, 1967 and US-SHS, 1954). To assess soil condition, measurement of pH and EC provide important information. Experimental results of pH and Electrical Conductivity of soil samples of study area at Hazaribagh, Dhaka are presented in the **Table 1**. This table represents the number of sample lies in low, medium to high pH range. Twenty four samples were collected from different depth (10, 30, and 90 cm) of eight different places and one was collected from tannery wall. Experimental results show that most of the samples were in medium to high pH range. Among them seventeen samples were in medium pH and five samples were in high pH range. The samples collected from tannery were in high pH range comparing with the soil samples collected from outside of tannery area. The pH values of the samples collected from Baribadh, Kalunagar, Moyla factory area were also high like the soil of tannery area. Although this place is far from tanning industrial area, but tannery effluents flowed from the canal to the Buriganga River through this area. During heavy rain effluents overflowed at this area. That is why pH values are high. The pH value of three samples in Jeans Dying Ltd. was 6.35 to 6.48 range. Jeans Dying industry is located in the Tannery area and once it was a tannery. But more than twenty years back tanning process was shut down and was replaced by dyeing industry. That might be a cause of lower pH range of its soil. Most of the samples of study area were in alkaline range and only one soil sample found in acidic range.

Electrical conductivity of the studied samples are also shown in Table 1. The EC values of the analyzed soil samples found to vary from 0.62 to 81.92 dSm^{-1} which indicated that the soil of studied area are non saline to moderately saline to high saline. The result shows that soils collected from Gajh Mahal school field and Kamrangir Chor are in non-saline range. These sampling points are far from the tannery area. Among the collected samples from tanneries, ten samples fell in the severely saline range and eight samples were found in very severely saline range comparatively in most of all depth (10 cm, 30 and 90 cm). EC and pH measurement of soils provided valuable information while assessing soils and EC correlated with soil properties that affect soil texture, cation exchange capacity, drainage conditions, salinity and organic matter level. US salinity staff laboratory state that soils with conductivity of the saturation extract (EC)> 4 dS/m at 25^{o}C, pH < 8.5 and exchangeable sodium percentage <15 are recognized as saline soil (Richards, 1954). Values of pH and EC may vary from season to season by climatic conditions. When totals salt concentration of soil, i.e. electrical conductivity (EC_{se}) exceeds 2 dS/m it is considered salt affected (Abrol et al., 1998). From the Table 1, it can be concluded that higher EC value reflects the higher amount of salt concentration and high pH generally reveals alkalinity of soils. EC value of the wall of Reliance Tannery was found 23.30 dS/m which is also in the severely saline range.

Table 1 pH and Electrical conductivity study of the soil of Hazaribagh industrial area (N= 25)

Sampling location name	Soil depth (cm)	Low pH samples	Medium pH samples	High pH samples	Non-saline EC_{se} samples (dSm^{-1})	Slightly saline EC_{se} samples (dSm^{-1})	Moderately saline EC_{se} samples (dSm^{-1})	Severely saline EC_{se} samples (dSm^{-1})	Very severely saline EC_{se} samples (dSm^{-1})
Chinese tannery	A1 (10 cm)		7.20						31.54
	A2 (30 cm)			8.20					39.00
	A3 (90 cm)		7.00					22.05	
K2 tannery	B1 (10 cm)			8.80					54.31
	B2 (30 cm)			8.30					35.52
	B3 (90 cm)		7.4						81.92
MI tannery	C1 (10 cm)		7.36						22.50
	C2 (30 cm)		7.44						18.21
	C3 (90 cm)		7.68				14.88		
Shahjalal tannery	D1 (10 cm)		7.28						28.78
	D2 (30 cm)			7.90					27.39
	D3 (90 cm)			7.88					29.67
Jeans Dying Ltd.	E1 (10 cm)	6.48						10.88	
	E2 (30 cm)	6.37							17.99

	E3 (90 cm)	6.35							25.18
Reliance tannery (Building Sample)	F		7.10					23.30	
Gajh Mahal School field	G1 (10 cm)		7.77		0.63				
	G2 (30 cm)		7.62		5.28				
	G3 (90 cm)		7.34		5.84				
Baribadh, Kalunagar, Moyla factory	H1 (10 cm)			8.08					28.18
	H2 (30 cm)			8.40					24.51
	H3 (90 cm)		7.44					18.63	
Kamrangir Chor, bank of Buriganga river	I1 (10 cm)		7.70				9.88		
	I2 (30 cm)		6.50		1.64				
	I3 (90 cm)		7.01		3.43				
Total samples	25	03	15	07	05	00	02	04	14

Some ions of soluble salts like Na^+, Cl^- and SO_4^{2-} in mg/kg were determined to know their amount in the soil and the observed values are shown in **Table 2**. Data revealed that the amount of Na^+ ion in soil of tannery area 74.43 to 261.23 mg/kg. The highest concentration was found in K2 tannery soil at 10 cm depth and lowest value was found in MI tannery at 30 cm depth. All the tannery soils contain Na^+ ion concentration more than 100 mg/kg except one sample which contains 74.43 mg/kg. The Na^+ ion concentration of Gajh Mahal School field and Kamrangir Chor, on the bank of Buriganga river ranged from 10.01 to 26.99 mg/kg which indicated that those samples are less contaminated with the tannery effluent. These two sample points are far from the tannery area.

The highest Cl^- ion concentration (7739 mg/kg) was found in K2 tannery at 10 cm depth and lowest (284 mg/kg) was found in Shahjalal tannery at the 30 cm depth. The Cl^- ion concentration of Kamrangir Chor, bank of Buriganga river at the different depth from the surface are comparatively lower (10.65 to 64.75 mg/kg) than those of the studied soils. The concentrations of SO_4^{2-} ion of the studied samples were found to vary from 50 to 2900 mg/kg at different levels.

Table 2 Study of some soluble salts (Na^+, Cl^- and SO_4^{2-}) from the soils of Hazaribagh industrial area (N = 25)

Sampling location name	Soil depth (cm)	Na^+ (mg/kg)	Cl^- (mg/kg)	SO_4^{2-} (mg/kg)
Chinese tannery	A1 (10 cm)	142.60	3000	2100
	A2 (30 cm)	170.52	4181	2250
	A3 (90 cm)	121.67	1486	900
K2 tannery	B1 (10 cm)	205.41	7739	2650
	B2 (30 cm)	191.45	6160	300
	B3 (90 cm)	261.23	2602	1475
MI tannery	C1 (10 cm)	144.77	852	1013.22
	C2 (30 cm)	74.43	1420	862.38
	C3 (90 cm)	113.05	1704	562.35
Shahjalal tannery	D1 (10 cm)	196.72	1136	2137.92
	D2 (30 cm)	100.9	284	1593.6
	D3 (90 cm)	129.73	852	1564.09
Jeans Dying Ltd.	E1 (10 cm)	177.50	568	1921.51
	E2 (30 cm)	146.97	1704	392.17
	E3 (90 cm)	183.72	2840	372.49
Reliance tannery (Building Sample)	F	112.11	177.5	900.00
Gajh Mahal School field	G1 (10 cm)	10.01	284	100
	G2 (30 cm)	23.97	568	750
	G3 (90 cm)	16.99	71	1000
Baribadh, Kalunagar, Moyla factory	H1 (10 cm)	135.62	2485	2900
	H2 (30 cm)	121.66	1917	1517
	H3 (90 cm)	100.73	1633	450
Kamrangir Chor, bank of Buriganga river	I1 (10 cm)	26.53	64.75	250
	I2 (30 cm)	10.01	10.65	50
	I3 (90 cm)	18.29	73	150

The maximum concentration of SO_4^{2-} ion was found 2900 mg/kg in Baribadh, Kalunagar, Moyla factory area at 10 cm depth from the surface. Tannery effluents flowed from Hazaribagh to the Buriganga River through this area and overflowed of effluent may be the main cause of high SO_4^{2-} content at the upper level of the soil of this area. The lowest concentration of SO_4^{2-} was found 50 mg/kg in Kamrangir Chor, bank of Buriganga river at the 30 cm depth from the surface indicated that this area is less contaminated with salts. The SO_4^{2-} ion concentration at the 10 cm depth of all the samples collected from tannery area were so high and the ranged from 1921.51 to 2900 mg/kg which shows that the soils at the upper levels are highly contaminated. The concentrations of Na+, Cl- and SO_4^{2-} in the soil of Reliance tannery wall were found 112.11, 177.50 and 900 mg/kg which indicated that the wall is salinity affected. Concentration of Cl^- ion in the studied samples is higher than Na^+ ion. Source of Cl^- not only sodium chloride, other componds like $CaCl_2$, $MgCl_2$, NH_4Cl, chlorinated phenol, polychlorinated biphenyl etc. are used in tannery and these are also possible source of Cl^- ion concentration. Major source of SO_4^{2-} is basic chromium sulphate which is the key chemical used in tanning industry and about 60-65% consumed in leather and rest of the amount discharged without treatment. H_2SO_4 and $(NH_4)_2SO_4$ are also used in the leather processing those are possible sources of SO_4^{2-} ion concentration.

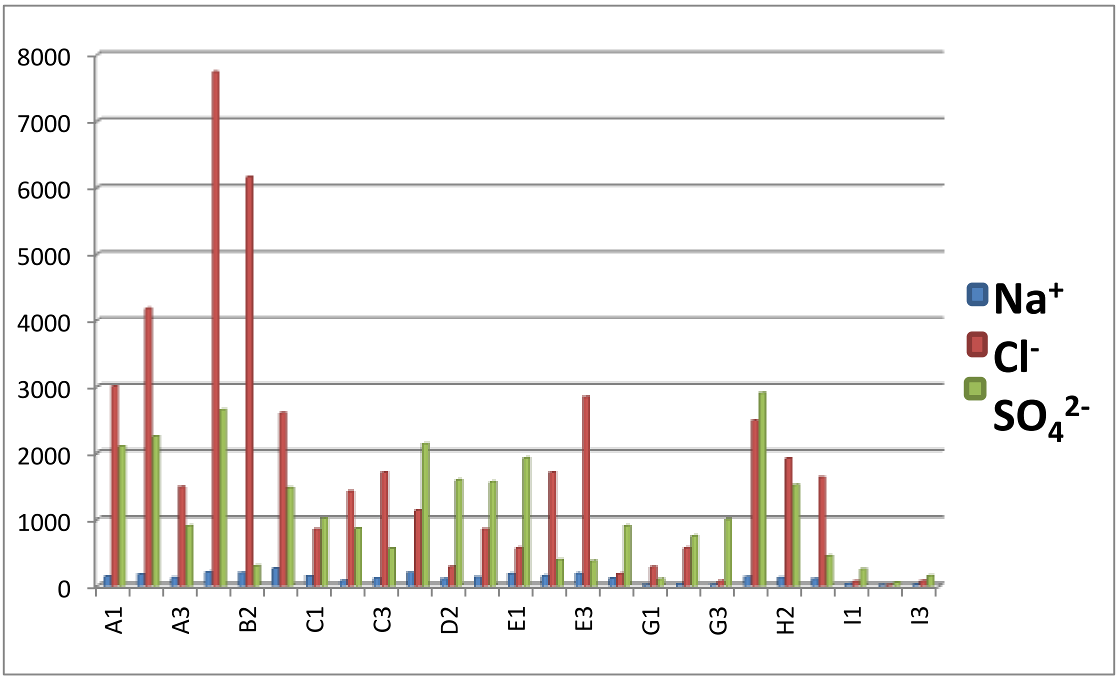

Fig. 2 status of salts ions (Na^+, Cl^- and SO_4^{2-}) in the soil of Hazaribagh Industrial Area.

Fig. 2 showed that Cl^- and SO_4^{2-} were found in higher amount comparing with other salts ion. Sehgal et al. (1980) found Na^+ in concentration in soil 690 mg/kg which is similar to the present study. Sehgal et al. (1980) and Bhargave et al. (1980) reported Cl^- ion concentration in soil were 315 and 360 mg/kg respectively while SO_4^{2-} content were 258 and 75 mg/kg. These values were lower than the present study.

Correlations

Table 3 Pearson correlation matrix of the parameters

	pH	EC	Na^+	Cl^-	SO_4^{2-}
pH	1				
EC	0.364	1			
Na^+	0.117	0.834**	1		
Cl^-	0.514**	0.645**	0.641**	1	
SO_4^{2-}	0.420*	0.540**	0.548**	0.402*	1

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

Pearson's correlation coefficient of pH, EC, Na^+, Cl^- and SO_4^{2-} ions in soil samples are summarized in Table 3. Correlation chart indicated that sodium is strongly correlated to EC (r = 0.834), Cl^- and SO_4^{2-} significantly positively correlate to Na^+.

Sulfates and chlorides are more aggressive to building materials and damage concrete through chemical reactions. When soil moisture enters into the concrete, it leads to rising damp and crystallization of salts (both chlorides and sulphates) after evaporation of water (Emmanual et al., 2012). Soils solutions high in SO_4^{2-} are corrosive to concrete structure and the amount of SO_4^{2-} was found in sampling area is pretty high. The sulfate solution reacts with calcium in the cement and destroys the integrity of concrete either changing into a non-cementing material or forming large crystals of $CaSO_4$. The potentiality of crystallization increases with salinity level and therefore leaves a potential pressure exertion on the rock materials (Winkler and Singer, 1972). Sodium and chloride are two most important elements in plants and where sodium is non-essential but beneficial, chlorine is essential but both are toxic in excessive concentration (Marscchner, 1995). Sodium affected soils usually have a greater pH and poor structure because sodium disperse the soil structure reducing the large pores which makes leaching very difficult (Flynn and Ulery, 2011). Salts are corrosive to metal which are commonly used in construction and rusting is a common affair in saline affected area. Deterioration is occurred to inorganic porous building materials due to salt induce and the intensity of deterioration depends on salt types, its content in building, porosity and the absorption of moisture (Cultrone et al., 2007 and Lubelli et al., 2004).

IV. Conclusion

Hazaribagh tanning industrial area is a most polluted area because of disposing tannery waste through open drainage system without any treatment. Due to this process, salt accumulation has occurred day by day and soil salinity of all sampling places of tannery area was found from severely saline to very severely saline range. Currently tanneries are shifting to another new place and this whole area will be vacant soon. This vacant area in near future will be commercial or residential area. In some vacant places, construction works has been already started but as the soils are in highly saline range, new construction or new building may be affected by salt rapidly if necessary steps are not taken and therefore it is necessary to take some actions to reduce salinity from the soils by using chemical or other process.

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