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PARTICLE SIZE DISTRIBUTION ANALYSIS AND PHYSICO-CHEMICAL CHARACTERIZATION OF CHENAB RIVER WATER AT MARALA HEADWORKS

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Abstract

The present study describes the environmental profile of the River Chenab at Marala Headworks regarding physico-chemical characterization and particle size distribution. Water samples from the selected stations were collected and analyzed for physico-chemical characteristics. To evaluate pollution status the parameters determined were temperature, pH, colour, TDS, TSS, turbidity, total hardness, Ca-hardness, Mg-hardness, nitrates, ammonia, sulphates, chlorides, fluorides, Fe, Zn, Cu, Pb and Na. The results indicated a wide variation of different parameters among the selected sampling stations.

Introduction

Particle suspensions play an important role in ecosystem dynamics and the transport of microbial and biogeochemical constituents. The role of particles in water quality and contaminant transport is widely recognized (Schillinger & Gannon, 1985). Sediment has been identified as the most widely occurring pollutant and the terms suspended sediment, total suspended solids, total solids, suspended solids, suspended material and non-settle able solids have been used interchangeably to describe the suspended solid-phase material. Sediment is comprised of particles derived from rocks, biological materials or chemical precipitates and can include pavement dust and particles, atmospheric dust, natural soils, traction sand and cinders, vehicle rust particles, brake pad and tire dust and particles, trash and plant material. Many heavy metals and other trace elements are associated with sediments (Bent *et al*., 2001). The particle size distribution (PSD) of particles dispersed in fluid, is a list of values or a mathematical function that defines the relative amounts of particles present, sorted according to size (Jillavenkatesa *et al*., 2001).

As the levels of TSS increase, a water body begins to lose its ability to support a diversity of aquatic life. Suspended solids absorb heat from sunlight, which increases water temperature and subsequently decreases levels of dissolved oxygen (Ginting & Mamo, 2006). Some cold water species, such as trout and stoneflies, are especially sensitive to changes in dissolved oxygen. Photosynthesis also decreases since less light penetrates the water. As less oxygen is produced by plants and algae, there is a further drop in dissolved oxygen levels. TSS can also destroy fish habitat because suspended solids settle to the bottom and can eventually blanket the river bed. Suspended solids can also harm fish directly by clogging gills, reducing growth rates and lowering resistance to disease. Natural movements and migrations of aquatic populations may also be disrupted (Aubrey, 1950).

Turbidity is a measure of water clarity; the more material suspended in water the less light can pass through the water column, thus more turbidity. Turbidity also affects the color of water, water temperature and concentration of dissolved oxygen (DO). Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. As the particles settle, they can blanket the lake bottom and smother fish eggs and benthic micro-invertebrates (Anon., 1991; 1992). A tight coupling between contaminated sediments and overlying water exists in lakes and coastal ecosystems through the process of sediment resuspension (Eadie, 1996). The correlation between TSS and NTU has been documented in several environments but the amount of scattering and the subsequent effect of particles on water clarity differ between environments (Gallegos, 2005). For some systems, the relationship between turbidity and total suspension is complicated by changes in particle characteristics and their light scattering properties. A change in particle density would change the contribution of similarly-sized particles to total mass while a shift in size distribution could change the suspension's light scattering properties without altering the total mass.

Present study was aimed to establish Environmental profile of the River Chenab at Marala Headworks through physico-chemical characterization and particle size distribution.

Materials and Methods

Based on the initial survey, 10 sampling points were selected to collect water samples. Spot or grab sampling and composite sampling procedures were employed. The preservation of the samples was carried out according to the "Standard Methods for the Examination of Water and Wastewater (Greenberg, 1992). The pH and TDS of water samples were measured using hand held pH / TDS- meter (HANNA Instruments Model # HI 9812). To determine Ca and Mg hardness, complex-metric titration was carried out while Na concentration in water samples was measured using Flame photometer (Jenway PFP-7). Nitric acid- Hydrochloric acid digestion method was used for pretreatment of water samples and trace metal analysis was conducted using Atomic Absorption Spectrophotometer (Model, Solaar 969). Suspended solids, turbidity, sulphate, nitrates and ammonia were determined by Photometric method, Attenuated Radiation Method, SPADNS Method, Sulpha Ver 4 method and Cadmium Reduction method using HACH Spectrophotometer DR/20/0, respectively (Anon., 2002). Particle size distribution analysis was carried out using Mastersizer 2000 MAL.

Results and Discussion

The average size of particles in the water samples collected from different sampling stations of River Chenab at Marala headwork's ranged from 0.89–0.169 mm, 0.60–0.102mm, 0.90–0.130 mm, 0.75–0.151 mm, 0.59–0.160 mm, 0.80–0.100 mm, 0.99–0.101 mm, 0.90–0.115 mm, 0.77–0.110 mm, 0.80–0.130 mm, respectively at sampling stations 1 to 10 (Table 1). The average particle size cited for rivers throughout the world ranges from 1.0 to 0.100 mm (Walling, *et al*., 2000). The pH value of the water body under study ranged from 7.0 to 7.48. At SS 1,3,4,5 7 & 10, the pH was almost constant i.e., 7.0. At sampling station (SS) 2 & 6, it was found to be 7.48 and 7.43, respectively (Fig. 1). The temperature of the water body under study was 19.9^{o}C. At SS 3, the temperature was the highest i.e., 20.2^{o}C, however, at rest of the SS, there was a very little decrease in the temperature (about 0.3^{o}C).

Table 1. Particle size ranges (mm) at different sampling stations of the River Chenab at Marala Headworks.

Sampling station (SS)	Particle size range (mm)
1	0.89–0.169
2	0.60–0.102
3	0.90–0.130
4	0.75–0.151
5	0.59–0.160
6	0.80–0.100
7	0.99–0.101
8	0.90–0.115
9	0.77–0.110
10	0.80–0.130

The levels of TDS in an aquatic body reflects the pollution burden and results into increased BOD and COD which in turn results in the depletion of oxygen from the water body (Jonnalagadda & Mhere, 2001). The total dissolved solids (TDS) in the area under study ranged from 70 to 95 ppm (Fig. 2). The graph shows a regular pattern of fluctuations of TDS with a decreasing trend along the SS 1 to 10. Although, the elevated levels of TDS are not considered as a major human health risk, yet these can affect the taste and odor of drinking water and overall quality of the water and soil (Jonnalagadda & Mhere, 2001; Kabir *et al*., 2010). The colour of the water body under study ranged from 70 to 98 TCU however, at SS 2, 5 and 8, the color remained the same. On the contrary, at SS 1, 3, 4, 6 & 7 the colour was a little bit darker ranging from 90 to 98 TCU. At the last two SS, the colour was intermediate (Fig. 2). The color falls within the range reported by other workers (Weibel *et al*., 1964). The total suspended solids (TSS) of the water body ranged from 60 to 90 ppm. The Fig. 5 shows a continuous decrease of TSS from SS 3 to 7. This is followed by gradual increase from 60 to 72 at SS 7 to 10 (Fig. 5). The total hardness of the water body under study ranged from 22 to 34 ppm. At SS 1, 4 and 7, total hardness was almost constant, whereas at the rest of the SS, the TH fluctuated between 25 to 30ppm except in the last sample where TH was 22 showing the downward trend of TH (Fig. 3).

Fig. 4 shows a regular fluctuating pattern of Ca hardness (ppm) as we moved from SS 1 to 10 with a range from 22 to 12, however, at the last three stations there is a downward trend of Ca hardness. At all the SS except 8 & 9, the range of Mg hardness (ppm) was very narrow i.e., between 10 and 13 though it was fluctuating but at the last three stations there is an upward trend of Mg hardness. Nitrates ranged from 4.7 to 3.0 at the SS 1-10. At the station 8, the nitrates were minimum whereas in other stations they fluctuated under narrow range between 3.5 and 4.7. Ammonia concentration (ppm) was found to be fluctuating at all the 10 SS as shown in the fig 5 exhibiting the range of 0.01 to 0.08 however, at SS 4 to 7 there was a sharp trend of increase from 0.01 to 0.08. Such variations in the water quality depend on the regional differences in climate, geology, land use and population distribution (Robson & Neal, 1997).

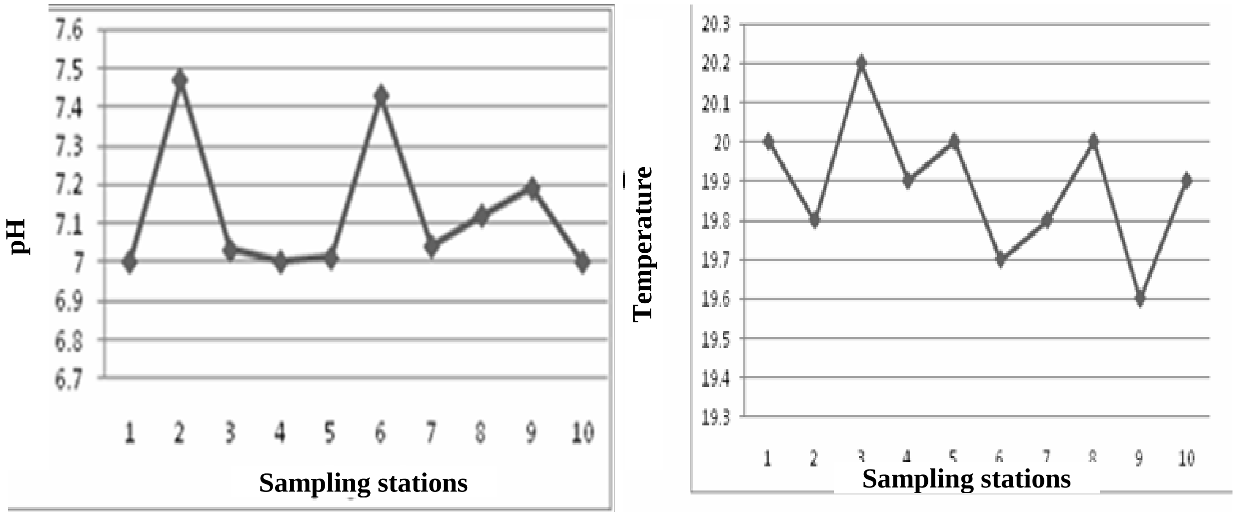

Fig. 1. Mean pH & Temperature (^oC) values obtained from different sampling areas of the River Chenab.

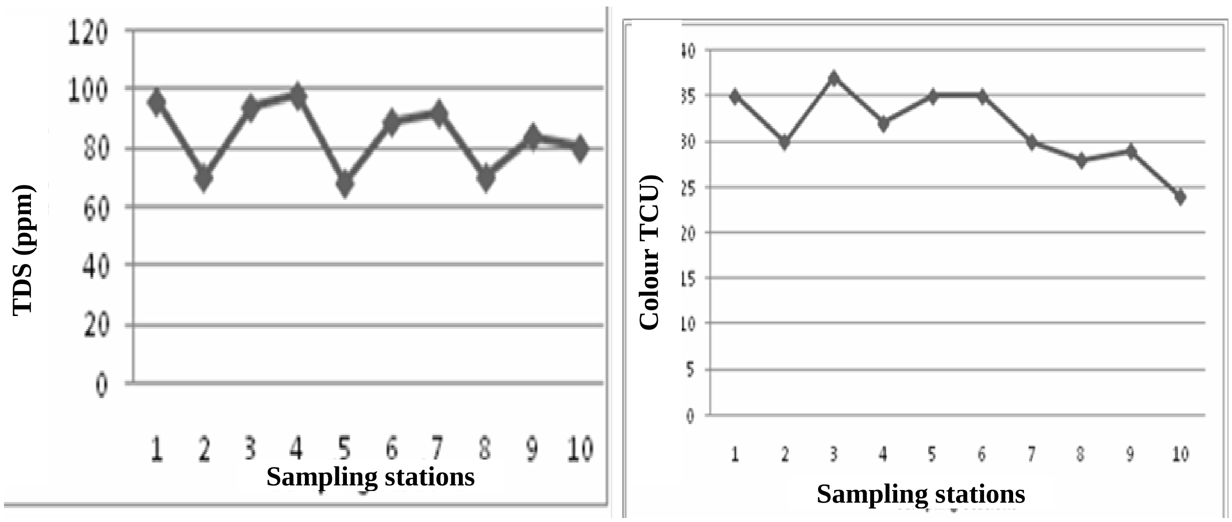

Fig. 2. TDS (ppm) & Color (TCU) of water observed at different selected sampling sites of the River Chenab.

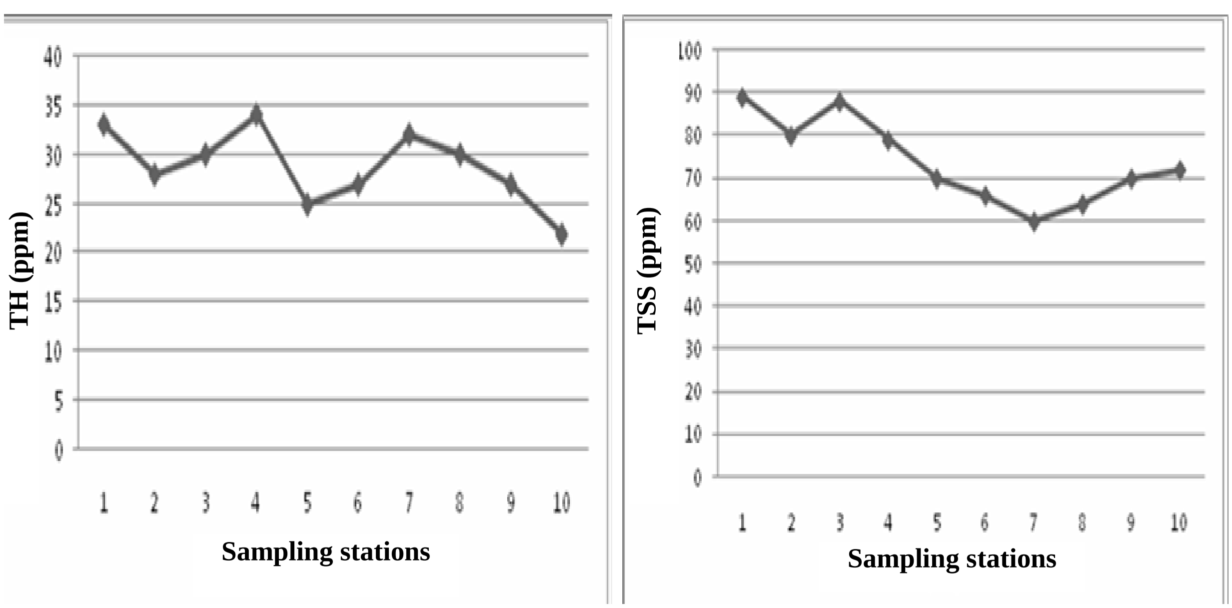

Fig. 3. Average Total Suspended Solids (TSS) & Mean Total Hardness (TH) in ppm calculated at selected sampling sites of the River Chenab.

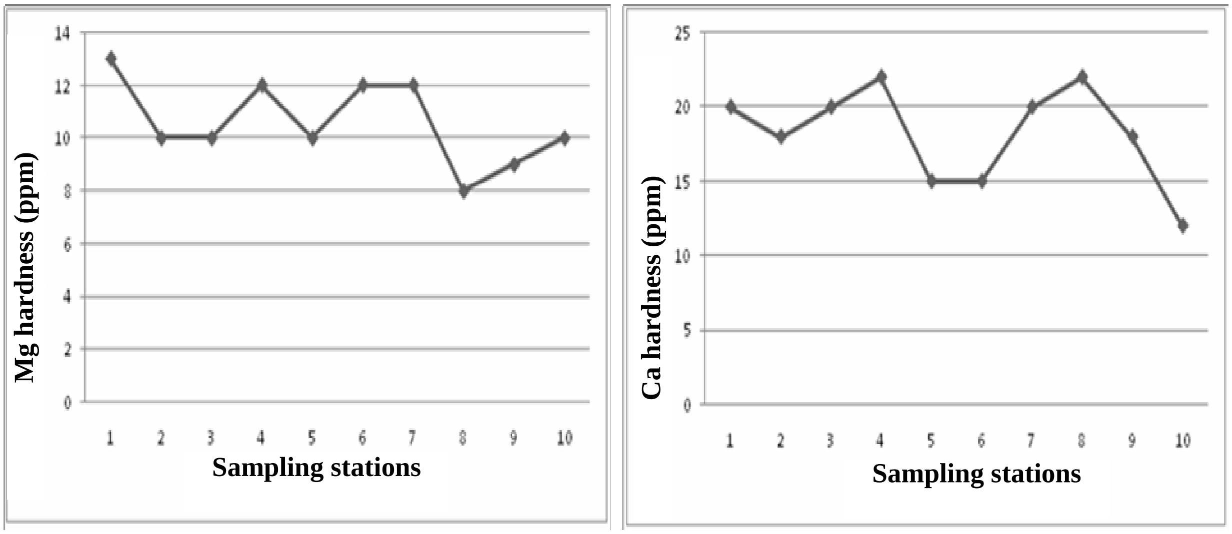

Fig. 4. Average Ca & Mg hardness in ppm calculated at different selected sampling sites.

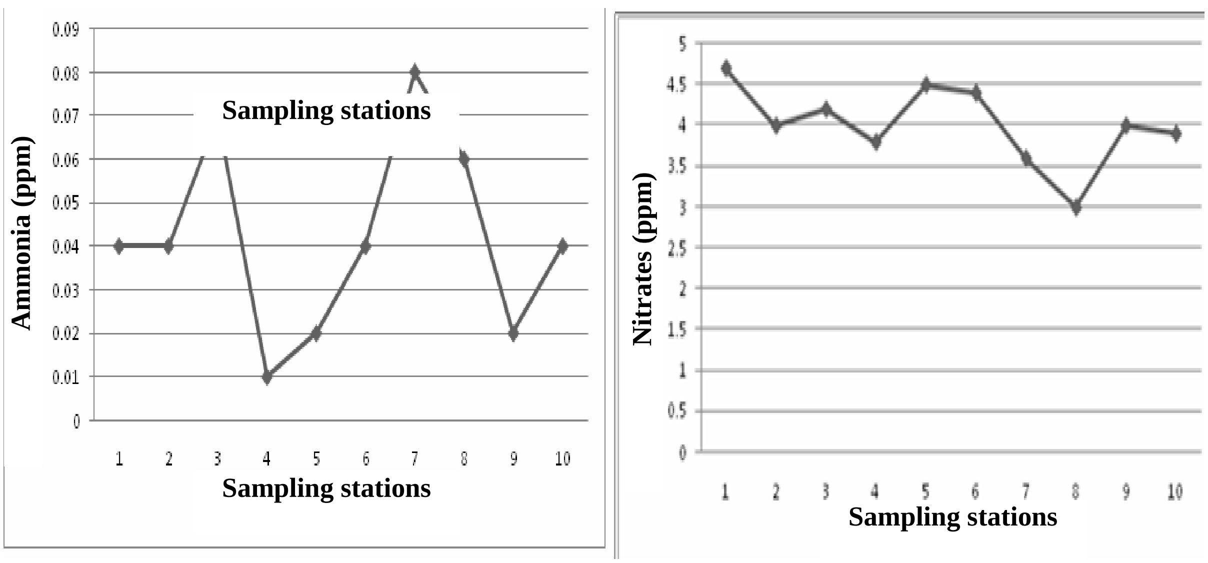

Fig. 5. Average Nitrates & Ammonia (ppm) calculated at different sampling sites of the River Chenab.

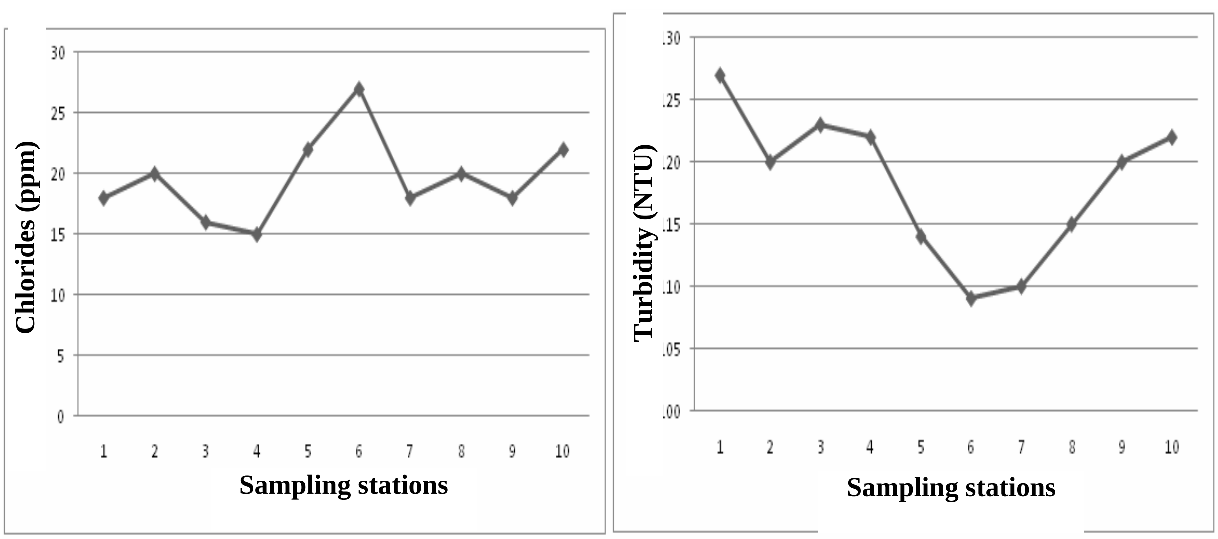

Fig. 6. Turbidity (NTU) & Chlorides (ppm) calculated at various selected sampling sites of the River Chenab.

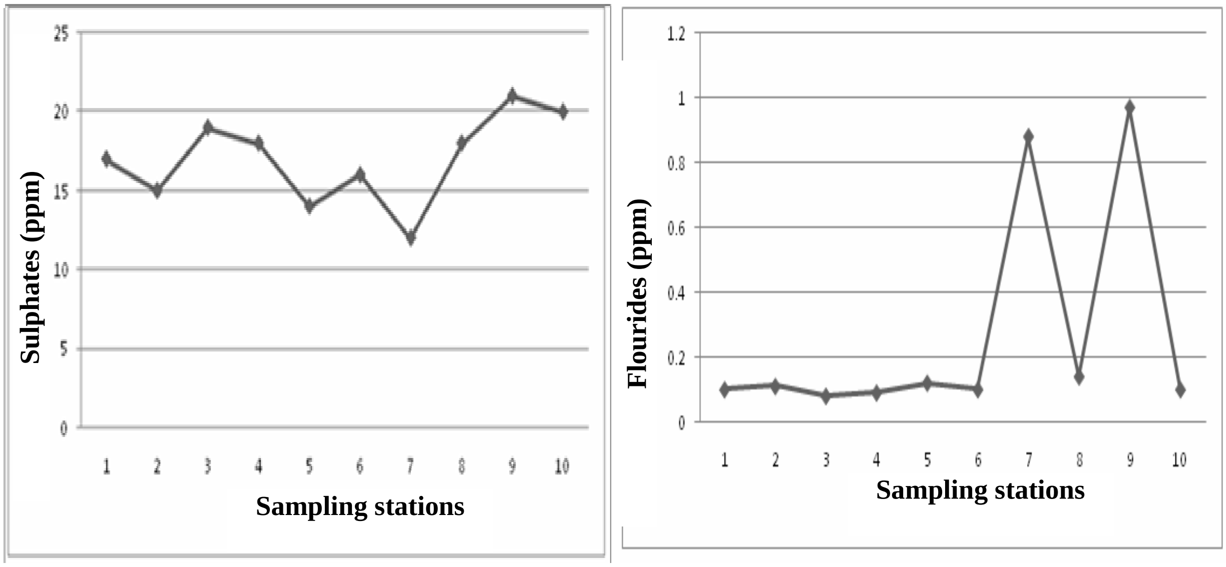

Fig. 7. Average Fluorides & Sulphates in ppm calculated at different sites of sampling of the River Chenab.

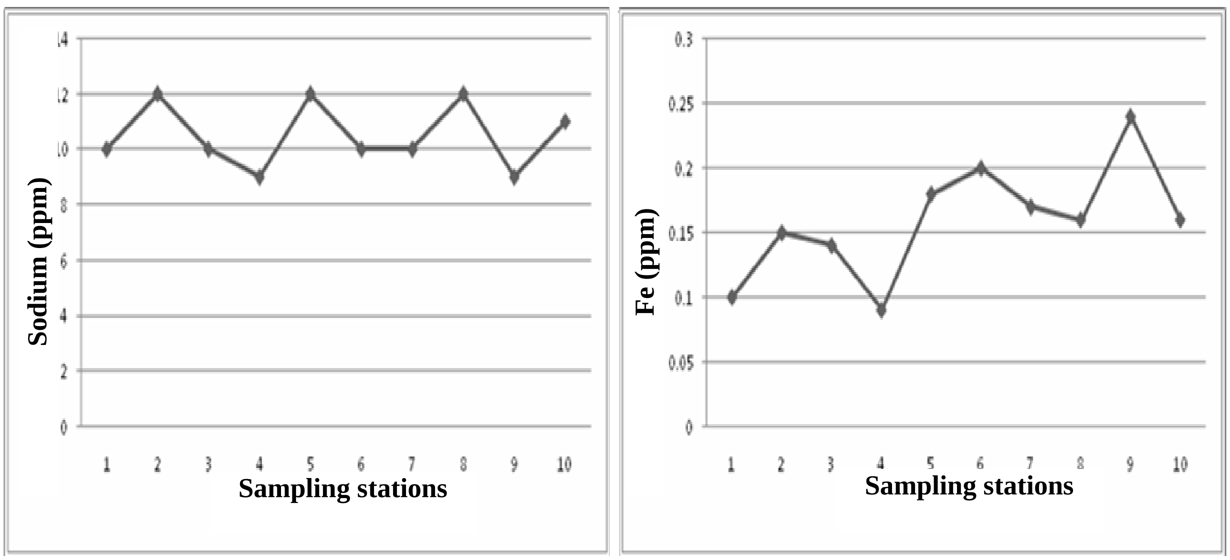

Fig. 8. Average iron & sodium contents in ppm calculated at different sites of sampling of the River Chenab.

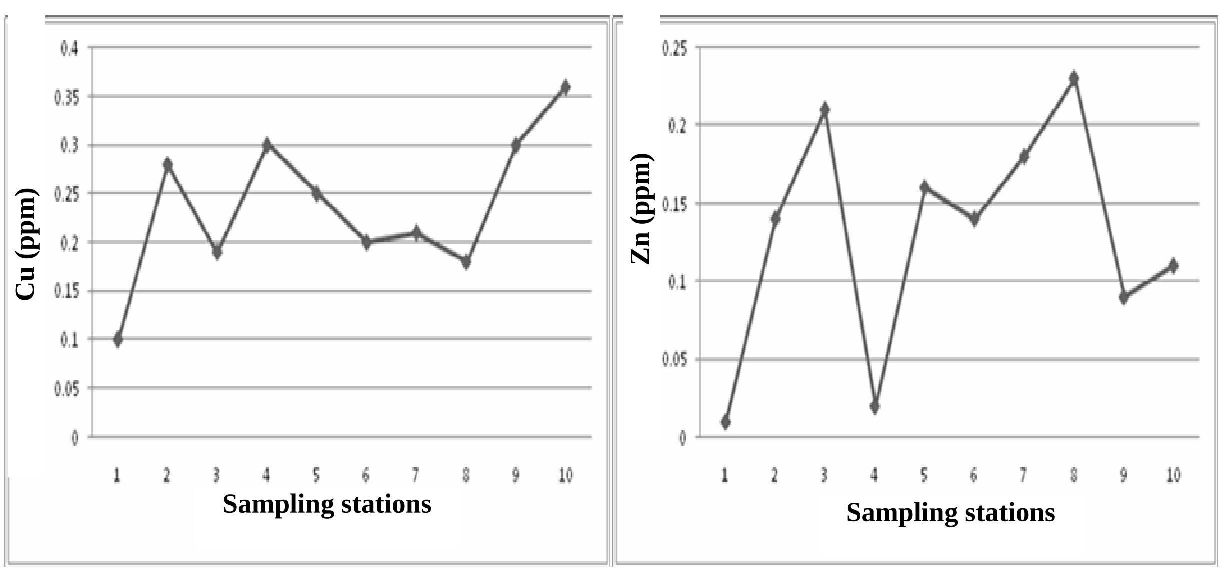

Fig. 9. Average Zinc & Cu contents in ppm calculated at different sites of sampling of the River Chenab.

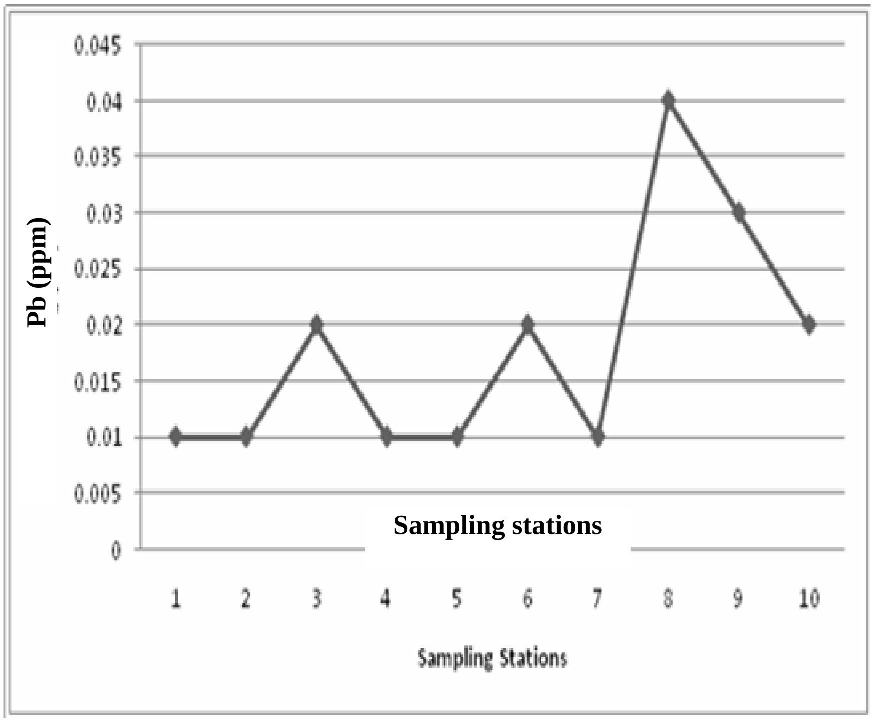

Fig. 10. Average lead contents calculated at different sampling sites of the River Chenab.

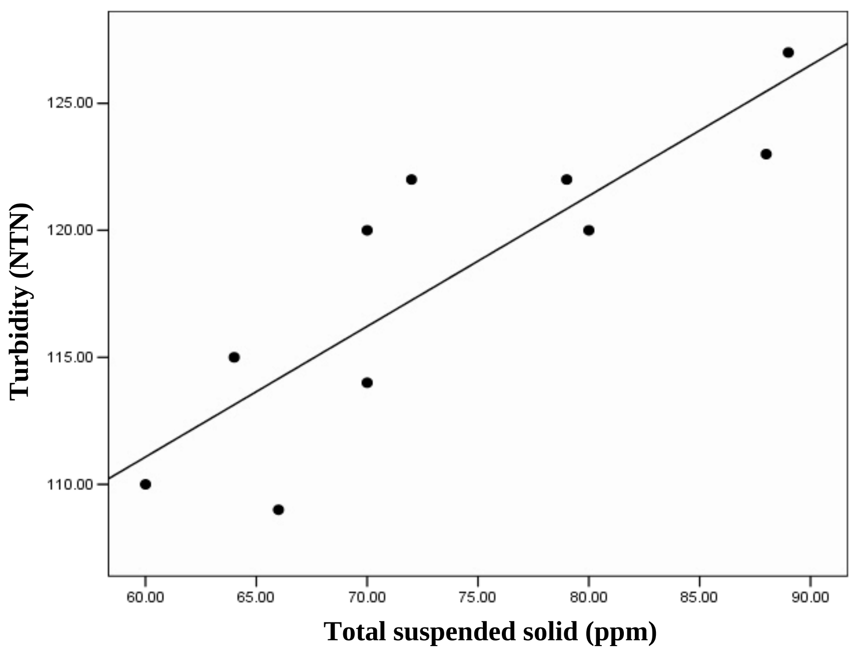

Fig. 11. Regression line between Turbidity and Total suspended solids.

The turbidity was found to be between 110 and 127 NTU in the selected 10 SS as evident from Fig. 6. The lowest turbidity was at SS 6 and 7. A certain turbidity level must be maintained in naturally turbid water systems but it should not be allowed to increase beyond certain limits which may deteriorate the water quality (Llyod, 1987). The chloride concentration (ppm) was found to be fluctuating within narrow range i.e., between 15 and 22 except at SS 6 where it was 27. The fluorides (ppm) remained constant in the first 6 and at 8^{th} and 10^{th} SS (Fig. 7), whereas at 7^{th} and 9^{th} SS it is beyond 0.8. The sulphates (ppm) present in the area under study ranged from 12 to 22. Minimum concentration was found at SS 7 and maximum at 9, whereas at rest of the SS the sulphates concentration remained between 14 and 20 ppm (Fig. 7).

The Iron (Fe) concentration in the test area under study ranged from 0.08 to 0.24, however, at SS 2, 3, 5, 6, 7, 8 and 10, iron concentrations ranged between 0.14 and 0.2. At SS 1 & 4, it was almost 0.1 and at SS 9, Fe concentration was the maximum i.e., 0.24 (Fig. 8). The sodium concentration was found to fluctuate in a very narrow range i.e., between 9 to 12 ppm in the area under study. At eight sampling stations, the concentration of Zn was ranged between 0.09 and 0.23 in ppm. However, at SS 1 and 4, Zn was found in very low concentration (Fig. 9). Copper concentration (ppm) was found to be fluctuating between 0.1 and 0.36 in the selected sampling stations. At 8 stations, the range was 0.18 to 0.30 (Fig. 9). Such fluctuations in the metal content are due to the fact that their concentrations are increased during periods of high flow and vice versa (Brown, 1977). The lead (Pb) concentration ranged between 0.01 and 0.02 in eight SS except at two stations 8 and 9, where it was 0.04 and 0.3 respectively (Fig. 10). All these contaminants have originated from the industrial or domestic sources and some such as zinc, lead and copper may come from either mine contaminated sediments or from weathering of bedrock (Robson & Neal, 1997).

Based on the above data, regression analysis was carried out using SPSS software. The analysis shows R^2 73.6 % and the P value was calculated to be 0.002 which is > 0.05. Our data fits the simple regression model on the regression line i.e., Turbidity= 80.24+0.514 TSS as shown in Fig. 11. Based on the results we can work out the turbidity from TSS or vice versa. Correlation analysis was also carried out from the data. There exists a highly significant correlation between Ca hardness and total hardness (TS); turbidity and total suspended solids (TSS) and Sodium and total dissolved solids (TDS). Apart from this, a significant correlation occurs between Mg hardness and total dissolved solids (TDS); chlorides and Ca hardness; chlorides and total hardness (TH).

References

Anonymous. 1991. *Volunteer lake monitoring: A method's manual. EPA 440/4-91-002*. Office of Water. U.S Environmental Protection Agency, Washington, DC.

Anonymous. 1992. *Standard Methods for the examination of water and waste water*. 18^{th} edition, American Public health Association, Washington, DC.

Anonymous. 2002. *Water Analysis Handbook*, 4^{th} Edition, HACH Company, pp. 669-712, Loveland Colorado, U.S.A.

Aubrey, T.H. 1950. *Manual of British water supply practice*, Institution of water Engineers W. Heffer & Sons Ltd. Cambridge.

Bent, J., C. Gardner, R. John, L. Gray, P. Kirk, G. Smith and G Douglas. 2001. A Synopsis of Technical Issues for Monitoring Sediment in Highway and Urban Runoff, *USGS*, OFR 00-497

Brown, B.E. 1977. Effects of mine drainage on the river hayle, cornwall a) factors affecting concentrations of copper, zinc and iron in water, sediments and dominant invertebrate fauna. *Hydrobiologia*, 52(2-3): 221-233.

Eadie, B.J., D.J. Schwab, G.A. Leshkevich, T.H. Johengen, R.A. Assel, N. Hawley, R.E. Holland, M.B. Lansing, P. Lavrentyev, G.S. Miller, N.R. Morehead, J.A. Robbins and P.L. Van Hoof. 1996. *Recurrent Coastal Plume in Southern Lake Michigan, EOS.*, 77: 337-338.

Gallegos, C.L., T.E. Jordan, A.H. Hines and D.E. Weller. 2005. Temporal variability of optical properties in a shallow, eutrophic estuary: Seasonal and inter annual variability, *Estuarine Coastal Shelf Science*, 64: 156-170.

Ginting, D. and M. Mamo. 2006. Measuring runoff-suspended solids using an improved turbidometer method. *Journal of Environmental Quality*, 35: 815-823.

Greenberg, E., L.S. Clesceri and A.D. Eaton.1992. *Standard method for examination of water and waste water*. 18th Edition. American Public Health Association, Washington, DC Section.

Jillavenkatesa, A., S.J. Dapkunas, L. Lin-Sien. 2001. Particle Size Characterization, *NIST Special Publication*, 960-71.

Jonnalagadda, S.B. and G. Mhere. 2001. Water quality of the Odzi River in the eastern highlands of Zimbabwe. *Water Res.*, 35(10): 2371-76.

Kabir, M., M.Z. Iqbal, Z.R. Farooqi and M. Shafiq. 2010. Vegetation pattern and soil characteristics of the polluted industrial area of Karachi. *Pak. J. Bot*., 42(1): 661-687.

Llyod, D.S. 1987. Turbidity as a Water Quality Standard for Salmonid Habitats in Alaska, *North American J. Fisheries Management*, 7: 34-45

Robson, A.J. and C. Neal. 1997. A summary of regional water quality for Eastern UK Rivers. *Sci. Total Environ*., 194-95: 15-37.

Schillinger, J.E. and J.J. Gannon. 1985. Bacterial adsorption and suspended particles in urban stormwater. *Journal of Water Pollution Control Federation*, 57: 384-389.

Walling, D.E. 2000. The particle size characteristics of fluvial suspended sediment in the Humber and Tweed catchments, *UK Science Total Environment*, 251/252: 205-222.

Weibel, S.R., R.J. Anderson and R.L Woodward. 1964. Urban Land Runoff as a Factor in Stream Pollution. *Water Pollution Control Federation*, 36(7): 914-924.

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