Wastewater and soil quality assessment of Nullah Lai of Pakistan

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Abstract

The present study examines the extent of pollution in Nullah Lai water and surrounding soil due to untreated industrial and sewage waste. The main objective of this study is to assess the current concentration levels of trace elements and to compare and correlate heavy metal concentration in wastewater of Nullah Lai and soil of surrounding area, where different type of vegetation are grown. Ten wastewater and soil samples were collected from the ten different localities of Rawalpindi; Marihassan (M.H), Khyaban e sirsyed (KSS), Chaklala Scheme 3 (Ch.Sch 3), Dhok Chargaeddin (Civil Lines) (Dhok Cd), Sawan (SW) and Islamabad; Kahuta Road (K.R), Ghor town (Lehtrar road) (G.T), Ali trust (A.T), Narc Colony (N.C), Faizabad (FB). The concentrations of heavy metals (Cu, Cd, Pb, Zn, Ni and Cr) were determined by atomic absorption spectrophotometry. The physical parameters pH, Electrical conductivity (EC), total dissolved solids (TDS), turbidity and temperature in water and soil samples were also determined at the site. Higher values of heavy metals (Cd, Cr, Ni, Pb, Zn, Cu) and other physical parameters (pH, EC, Turbidity, TDS, Temperature) in wastewater and soil samples clearly indicate the industrial and sewage pollution. Correlation analyses were performed by Pearson’s product moment correlation. The results showed that there is highly significant positive correlation between different soil and wastewater samples of different sites of Rawalpindi and Islamabad. This indicated that the increase in contamination in wastewater of Nullah Lai cause to increase the toxicity level of soil in that area. It causes to contaminate not only the surface and groundwater but also increase the toxicity level of soil. The present investigation also proved that the wastewater are not able to be use for drinking purpose due to high toxic level of heavy metals as prescribed by World Health Organization (WHO) guidelines but can be used for irrigation purpose after proper treatment.

Keywords: Heavy metals, Physiochemical analysis, Metroplitan cities, Wastewater, Drain water, Effluents, sewage water, contamination.

INTRODUCTION

Biosphere pollution by chemicals and heavy metals such as cadmium, nickel, zinc, lead, copper, etc is accelerated dramatically during the last few decades due to mining, smelting, manufacturing use of agricultural fertilizers, pesticides, municipal wastes, traffic emissions, industrial effluents and industrial chemicals, etc (Lobersli and...
The rapid increase in population together with unplanned industrial effluent discharge has increased the threat of soil pollution in Pakistan. The outcome of this pollution includes soil degradation along with a decreased biodiversity, irreversible extinction of many sensitive organisms and the selection of adaptable ones (Mufti et al., 1997). The metals ions of transition metals essential for life include vanadium, manganese, iron, cobalt, nickel, copper, zinc, and molybdenum. These metal ions play a variety of functions in biological systems as important structural components in proteins. But higher levels of these metal ions are highly toxic to animals including humans as well as plants and their solubility in water is considered to be one of the major environmental issues. Heavy metals are ubiquitous environmental contaminants in industrialized societies. Soil pollution by metals differs from air or water pollution because heavy metals persist in soil much longer than in other compartments of the biosphere (Lasat 2002).

Further, the use of wastewater and sludge in agricultural lands was found to enrich soils with heavy metals to concentrations that may pose potential environmental and health risks in the long-term (Sánchez-Martín et al., 2007; Tabari et al., 2008). Nwuche and Ugoji (2008) found heavy metal concentrations adversely affected the biological health of the soil manifested in lower rates of nitrogen mineralization, lower soil microbial biomass carbon and reduced rate of respiration by soil microbial population. It is true that heavy metals commonly enter soils through addition of sludge (e.g from treated waste water), composts, or fertilizers (Kirkham, 2006; Kaonga et al., 2010). But the risk is still there that some residual heavy metals may get into the soil and crops through the treated wastewater itself. Although a number of studies has been carried out on various aspects of the system (Li et al., 2001; Cornish and Kielen, 2004; Emongor and Ramolemana, 2004; Samarghandi et al., 2007), knowledge is still limited on its impact on soils and the associated heavy metal accumulation in soils. Thus, there is need for more studies focused on the benefits and limitations of the use of wastewater for irrigation (Kirkham, 2006).

In Pakistan registered industries are registered and 1228 are considered to be highly polluting. The major industries include textile, pharmaceutical, chemicals (organic and inorganic), food industries, ceramics, steel, oil mills and leather tanning which spread all over four provinces, with the larger number located in Sindh and Punjab the physical, chemical and biological characteristics of air, water and soil, finally. A great global threat is environmental pollution and various undesirable changes due to it affecting human, animals and plants life (Misra and Dinesh, 1991). The rapid industrialization is accompanied by both direct and indirect adverse effect on environment (Nasrullah et al., 2006). Industrial development (Either new or existing industry expansion) results in the generation of industrial effluents, and if untreated results in water, sediment and soil pollution (Fakayode and Onianwa, 2002; Fakayode, 2005). It has been observed that a wide majority of industries discharge untreated effluent into river and only 10% industries had primary treatment plants ranging from oxidation tanks, sedimentation tanks in developing countries (Dada 1997). Having mainly excessive amounts of heavy metals such as Pb, Cr and Fe (Ahmed, 2000).

Heavy metals from industrial processes are of special concern because they produce water or chronic poisoning in aquatic animals (Ellis, 1989). Heavy metals are natural constituents of natural waters; some are present at low concentrations and number are biologically important in the aquatic environment. They enter natural waters from various sources. Natural geological weathering of rocks and soil, directly exposed to surface waters, is usually the largest natural source. Another source is anthropogenic input from mining, domestic and industrial activities such as corrosion of copper tubing and discharge from waste water from electroplating smelting and metal engraving industries. They are adsorbed onto deposits and incorporated into sediment resulting in elevated levels of heavy metals in bottom sediment (Chan 1995a; Cheevaporn et al., 1995; Borg and Jonsson 1996; Joen et al., 2003; Schmitt et al., 2003).

Rawalpindi city, having population of 1.6 million, generates approximately 70 MG of wastewater daily. Presently only 35 % of the total wastewater is being collected by RWASA and the remaining 65% of the wastewater is being disposed off into open drains that ultimately drain off into Nallu Lai – the main natural drainage channel passing through the city, thus causing alarming environmental hazards for the residents of Rawalpindi. Lai Nullah also carries a large quantity of untreated and a partially treated sewage from Islamabad and cantonment area (Islam-ul-haq et al., 2007).

Lai Nullah, commonly called Nullah Lai, is a rain water fed natural stream flowing through the city of Rawalpindi. Every monsoon season the stream floods after being fed by its catchment basin in the Margalla Hills bordering Islamabad, Pakistan. The Lai Nullah Basin has a catchment area of 234.8 km2, extending to the twin cities of Islamabad and Rawalpindi. Total sewerage coverage in Rawalpindi is about 35%.Due to the geological sub soil conditions of the sub-surface strata, wastewater (0.545 million m3/day) flowing in Nullah Lai (main recharge source) easily gets into fissured bed rocks and transport associated contaminants through flow nets into deep aquifer, causing ground water contamination. Over extraction of ground water is exposing upper aquifer, which allows contaminant transport associated with wastewater flowing in open drains and Nullahs and ultimately causing ground water contamination.
Nullah Lai flowing with the sewage water generated from Islamabad and Rawalpindi does not create any problem in terms of flood but when combined with heavy rainfall in the catchment areas it could have devastating impacts on the residents of Rawalpindi city.

The industrial pollution is a major problem in all big cities of Pakistan. However, severe problems are arising in Karachi, Lahore, Faisalabad, Sheikupura, Kasur, Multan, Hyderabad, Peshawar, Rawalpindi and Islamabad (Ambreen 1993). There are number of industries functioning in Rawalpindi and Islamabad, like oil refinery, textile mills, marble crushing units, flour mills, soap and detergent, hydrogenated oils, automobiles, steel and electroplating and rubber industries. Textile industries consume large amount of water (60–400 l/kg of fabric) and chemicals for wet processing (AEPA, 1998). The inputs of wide range of chemicals, which, if not incorporated in the final products (fabric), become waste and turn out to be part of water ecology. This study was undertaken with the following objectives:

- To assess the current concentration levels of trace elements.
- To highlight the contamination status of soil and water.
- To determine the nature and extent of pollutants in Lai Drain surface water and their effect on ground water of the area.
- To compare heavy metal concentration in water and soil where different type of vegetation are grown.

**EXPERIMENTAL METHODOLOGY**

**Study area**

Lai drain, passed from Rawalpindi and Islamabad was selected for detailed phytosociological study and heavy metal assessment in water and soil present in study area. The area from where Nullah Lai crossed in Rawalpindi and Islamabad was divided into ten sites. Total ten sites of metropolitan city were used for the collection of samples. The study area of present study was Nullah Lai passed from Rawalpindi and Islamabad. In Rawalpindi, the wastewater and soil samples were collected from following points of Nullah Lai:

1. Marir hassan (M.H)
2. Khyaban e sirsyed (KSS)
3. Chaklala Scheme 3 (Ch.Sch 3)
4. Dhok Charghdin (Civil Lines) (Dhok Cd)
5. Sawan (SW)

In Islamabad, the wastewater and soil samples were collected from following points of Nullah Lai:

1. Kahuta Road (K.R)
2. Ghorí town (Lehrtrar road)(G.T)
3. Ali trust (A.T)
4. Narc Colony (N.C)
Sample Collection

Waste water samples were collected from ten different locations along the waste water stream running along the metropolitan city of Islamabad and Rawalpindi. Ten locations were selected for sampling from the drain. Samples were collected in one-litre acid washed polyethylene bottles. Samples bottles were pre-cleaned and rinsed thoroughly with 10% of concentrated HNO₃ and distilled water. A sample of 500 ml of water was taken by immersing the bottles and lifting up and was mixed with 2 ml of concentrated HNO₃ to lower the pH of the water to <pH2. At each site, additional samples of water were taken for analysis of Color, odor, pH, electrical conductivity, total dissolved solid and turbidity and these parameters were determined on the site with the portable meter. Soil at surface level (0-15cm in depth) were collected.

Sample preparation

Water samples were filtered through 0.45µm pore size cellulose acetate filters and stored at 4°C before analysis. This procedure was believed to be able to prevent microbial growth, flocculation and reduce any adsorption on container surfaces. Surface soil samples were air-dried and ground into fine powder using pestle and mortar and passed through 1 mm sieve. Well-mixed samples of 1 g each were taken in 50 ml digestion flasks and digested with 10 ml aqua regia. The flask was placed on hot plate in a digestion chamber and temperature was gradually increased up to ~ 230°C. The flask was heated at this temperature until the production of brown NO₂ fumes ceases and dense white fumes of HClO₄ appeared in the flask. After evaporation to near dryness, the samples were diluted with 50 ml distilled water.

Sample analysis

EC and pH, total dissolved solid and temperature of water and soil samples were measured on site by using portable meter (Tandon et al., 2005). Turbidity of wastewater samples were measured by using turbidity meter. Heavy metal analysis of wastewater samples and digested soil samples were carried out using flame atomic absorption spectrophotometer (Wright and Stuczynski, 1996). The calibration curves were prepared separately for all the metals by running different concentrations of standard solutions. The instrument was set zero by running the respective reagent blanks. Average values of three replicates were taken for each determination. The detection limits for Zn, Cu, Ni, Cr, Pb and Cd were 0.008, 0.025, 0.04, 0.05, 0.06 and 0.009 (mg l⁻¹) respectively. Anam et al. 21

Statistical analysis

Correlation analyses were performed by Pearson’s product moment correlation. For samples with values below the detection limit, half of the respective limit of quantification was substituted to perform statistical analysis. The value of P < 0.05 was regarded as statistically significant for water and soil measurements.

RESULTS AND DISCUSSION

In this study, the concentrations of Cu, Cd, Pb, Zn, Ni, Cr and the physical parameters color, odor, pH, EC, TDS, turbidity and temperature in wastewater and soil samples were determined. The color and odor of the wastewater was determined by vision and smell. The turbidity, pH and EC was measured with portable meter on site.

In Rawalpindi area, at M.H, the color of wastewater light yellowish and smell was pungent and turbidity was 248 NTU. At KSS, the wastewater observed was colorless and smell was slightly acidic. The turbidity measured was 94.6 NTU. At Ch.Sch 3, the color of the wastewater samples observed was light yellowish and odor was slight pungent. The turbidity measured was 325 NTU (Table 1). Present findings are similar to the observations of Akan et al., 2008. According to the WHO standards if turbidity values are not above 5 NTU then is possible to discharge wastewater into the stream and possible to utilize for irrigation purposes. At Dhok. Cd, the color of the water observed was light yellowish and odor was pungent. The turbidity of the wastewater measured was 360 NTU. At S.W, the color of the water was yellowish and odor was pungent and slightly acidic. The turbidity measured was 268. The results showed that the wastewater characteristics are above the limits of WHO, so that it cause to increase the contamination level of the area at the highest rate.

In locations of Islamabad where sampling has been carried out, the color and odor of the wastewater observed was slightly yellowish and odorless. The turbidity measured at K.R was 37.5 NTU. At G.T, the color of the water observed was light brown, odor was slightly acidic. The turbidity measured was 243 NTU. It shows the highest level of turbidity in wastewater which shows the toxic level of contamination that pollutes the water and make it unable to be use for other purposes. At A.T, the color of the wastewater was transparent and odor was pungent. The turbidity range measured was 40.8 NTU. At N.C, the color of the wastewater was transparent and smell was pungent like. The turbidity of the water at N.C was not detected. At F.B, the color of the wastewater observed was transparent and smell was pungent. The turbidity measured at F.B was 108 NTU.
Table 1. Analysis of Physical Parameters of wastewater samples

<table>
<thead>
<tr>
<th>Locations</th>
<th>Color</th>
<th>Odour</th>
<th>Turbidity (NTU)</th>
<th>Locations</th>
<th>Color</th>
<th>Odour</th>
<th>Turbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.H</td>
<td>Light Yellow</td>
<td>Pungent</td>
<td>248</td>
<td>K.R</td>
<td>Light Yellow</td>
<td>Odorless</td>
<td>37.5</td>
</tr>
<tr>
<td>KSS</td>
<td>Colorless</td>
<td></td>
<td>94.6</td>
<td>G.T</td>
<td>Light Brown</td>
<td>Acid like smell</td>
<td>243</td>
</tr>
<tr>
<td>Ch.Sch 3 Dhok.</td>
<td>Light yellow</td>
<td>Pungent</td>
<td>325</td>
<td>A.T</td>
<td>Transparent</td>
<td>Slightly acidic</td>
<td>40.8</td>
</tr>
<tr>
<td>Cd</td>
<td>Pale Yellow</td>
<td>Pungent</td>
<td>360</td>
<td>N.C</td>
<td>Transparent</td>
<td>Slightly acidic</td>
<td>N.D</td>
</tr>
<tr>
<td>S.W</td>
<td>Light Yellow</td>
<td>Acidic</td>
<td>268</td>
<td>F.B</td>
<td>Transparent</td>
<td>Colourless</td>
<td>108</td>
</tr>
<tr>
<td>NEQS</td>
<td>Colourless</td>
<td>Odourless</td>
<td>NEQS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Assessment of Physico-chemical parameters in wastewater of Nullah Lai.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Range</th>
<th>Mean</th>
<th>Drinking purpose</th>
<th>Irrigation purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Cd (mg/l)</td>
<td>0.005-0.048</td>
<td>0.024+0.016</td>
<td>&lt;0.002</td>
<td>0.002-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
<td>0.004</td>
<td>10;100%</td>
</tr>
<tr>
<td>Cr(mg/l)</td>
<td>0.05-0.148</td>
<td>0.09+0.033</td>
<td>&lt;0.001</td>
<td>0.001-</td>
</tr>
<tr>
<td>Pb (mg/l)</td>
<td>0.083-0.162</td>
<td>0.12+0.025</td>
<td>&lt;0.002</td>
<td>0.002-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
<td>0.004</td>
<td>10;100%</td>
</tr>
<tr>
<td>Cu(mg/l)</td>
<td>0.004-0.016</td>
<td>0.009+0.003</td>
<td>&lt;0.001</td>
<td>0.001-</td>
</tr>
<tr>
<td>Ni(mg/l)</td>
<td>0.05-0.14</td>
<td>0.10+0.02</td>
<td>&lt;0.001</td>
<td>0.001-</td>
</tr>
<tr>
<td>Zn(mg/l)</td>
<td>0.001-0.008</td>
<td>0.004+0.002</td>
<td>&lt;0.002</td>
<td>0.002-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1;10%</td>
<td>0.006</td>
<td>2;20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7.70%</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.97-19.70</td>
<td>9.31+3.65</td>
<td>&lt;6.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>EC(uS/cm)</td>
<td>20-1262</td>
<td>934+389</td>
<td>&lt;200</td>
<td>200-600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1;10%</td>
<td>1;10%</td>
<td>8.80%</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>19.7-807.7</td>
<td>598.8+247.1</td>
<td>&lt;500</td>
<td>500-2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3;30%</td>
<td>7.70%</td>
<td></td>
</tr>
<tr>
<td>Temp(oC)</td>
<td>19.5-20.4</td>
<td>19.94+0.297</td>
<td>&lt;15oC</td>
<td>15-20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.50%</td>
<td></td>
</tr>
</tbody>
</table>

Analysis of chemical parameters of wastewater samples

Table 2 shows contamination level of Nullah Lai wastewater samples. The wastewater samples were analyzed both for drinking and irrigation purpose. Because due to shortage of water, the people of the rural area. As according to the results, the range of cadmium in all wastewater samples was 0.005-0.048. The mean of all wastewater samples was 0.024. The results of Cd showed that wastewater is not able to be used for drinking purpose because all the samples lie in highly toxic range as according to permissible limit of drinking water. The results of Cd also showed that wastewater can be use for irrigation purpose, because some of the samples range lie in normal permissible limit recommended for irrigation by WHO. The range of Cr in all wastewater samples was 0.05-0.148. The mean range in all wastewater samples for chromium was 0.09. The results for chromium showed that wastewater is unable to be used for drinking purpose but can be used for irrigation purpose. The range of Pb in all wastewater
samples were from 0.083-0.162 and the mean was 0.12. The results of Pb showed that wastewater is unable to be used for both drinking and irrigation purpose because the range of all the wastewater samples were lie in toxicity level as compared with permissible limit recommended for drinking and irrigation purpose. The range of Cu lie from 0.004-0.016. The mean of all wastewater samples were 0.009. The Cu concentration in wastewater samples showed that wastewater is not fit for drinking purpose but can be used for irrigation. The range of Ni in all wastewater samples were 0.05-0.14 and the mean was 0.10. The results of Zn showed that wastewater can be used for irrigation but not best for drinking purpose. The high range of all the parameters indicate the high range of pollution in the area of Islamabad and rawalpindi.

In the present study, the range of pH lie from 7.97-19.70 and the mean of all wastewater samples was 9.31. The results showed that wastewater can be used for irrigation because most of the samples range lie with permissible limit recommended for irrigation. Mireles et al., (2004) observed that a high amount of organic matter and pH of 6.9-8.6 keep most trace elements immobilized. The EC range in all wastewater samples were from 20-1262. The mean of all samples was 934. EC values in present study were as higher and usually higher EC values indicate the presence of higher contents of dissolved salts in water (Abdullah et al., 2007). EC values are a good measure of the relative difference in water quality between different aquifers (Roscoe Moss Company, 1990). The recommended permissible limit for Electrical Conductivity (EC) is 300 $\mu$S cm$^{-1}$ (Jafari, 2008). Akan et al. (2008) stated that the mean conductivity values for the sampling point were higher than the WHO guideline values of 1000$\mu$S cm$^{-1}$ for the discharge of wastewater through channel into stream. Therefore, according to the above reference, the wastewater should not be discharge in the stream that make the streams more toxic and that is been used for the irrigation and also for the drinking purpose by the local people.

Most of the wastewater samples above the permissible limit recommended for both irrigation and drinking purpose. The range of TDS in all wastewater samples was 19.7-807.7 and the mean was 598.8. The range of TDS in all wastewater samples lie in permissible limit recommended for both drinking and irrigation water. High TDS in ground water may be due to ground water pollution when waste waters from both residential and dyeing units are discharged into pits, ponds and lagoons (Shyamala et al., 2008). Akan et al. (2008) observed TDS values of all the sampling points were higher than WHO standard and stated if TDS values are greater than 2000 mg/l then not possible to discharge wastewater into the surface water. In other study of Tasik Chini water samples showed that wastewater is not fit for drinking purpose as permissible limit recommended as WHO. However, wastewater is unable to be classified as very soft water (i.e <10mg/l) with very low calcium and magnesium ions. In comparison to other

from Tasik Chini showed a mean water hardness of 5.42mg/l (Ikusima et al., 1982) and other Malaysian freshwaters (Johnson 1967; Shuhaimi-Othman et al. 2006). Batayneh (2008) stated that Cu concentrations of water samples for both seasons are lower than the MPCL recommended by JISM (2008) (1.0mg/l) for drinking water. Mireles et al. (2004) observed the concentration for metals like Ni and Cr were too low and were not detected by AAS. Due to application of sewage sludge, industries and tanneries wastewater for many years, a large portion of soil around the Hudira drain, Lahore has been contaminated with heavy metals such as Cd, Cr, Cu and Ni (Younas et al., 1998). The range of temperature was 19.5-20.4$^\circ$C. The mean of wastewater samples was 19.94. These are changes in wastewater due to increase in rate of chemical reactions and nature of biological activities, since temperature is one of the factors that govern the assimilative capacity of the aquatic system (EPA, 1976; Forstner and Wittlman, 1979). The results showed that temperature range was higher in some of the wastewater samples as permissible limit recommended for both irrigation and drinking purpose. Wogu et al. (2011) stated that the result obtained in their study showed that cadmium, chromium, manganese and nickel had maximum values that were greater than recommended values by the Environmental Protection Agency (EPA, 2002) World Health Organization (WHO, 2003) and Standard Organization of Nigeria (SON, 2007). High concentrations of heavy metals in the aquatic ecosystems are found due to effluents from industries, refuse and sewage (Tarig et al., 1991; Egborne 1991; Ezemonye, 1992; Edema, 1993). The concentration levels of these metals would markedly impair the potability of the water. All of the above results showed that wastewater of Nullah Lai is unable to be use for drinking purpose but can be use for irrigation purpose.

Analysis of Physico-chemical parameters of soil samples

Table 3 shows the assessment of Physico-chemical parameters in soil samples at the vicinity of Nullah Lai. As according to the results, it has been observed that the range of Cd in all soil samples was 2.73-6.36 and the mean of all samples was 4.400. The results of Cd showed that all the soil samples lie in permissible limit range as recommended by WHO. Batayneh (2008) results indicate that most Cd concentrations for both dry and wet season water samples are lower than the maximum permissible limit recommended (Jordanian Institution for Standards and Metrology, 2008) (0.003 mg/l) for drinking water. As according to the results, the range of chromium in all soil samples lie from 8.60-66.57
Table 3. Assessment of Physico-chemical parameters in soil samples of Nullah Lai.

<table>
<thead>
<tr>
<th>Physio-chemical parameters</th>
<th>Range</th>
<th>Mean</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd (mg/l)</td>
<td>2.73-6.36</td>
<td>4.400+1.260</td>
<td>&lt; 3</td>
<td>3-6</td>
<td>&gt;6</td>
</tr>
<tr>
<td>Cr(mg/l)</td>
<td>8.60-66.57</td>
<td>29.61+18.12</td>
<td>&lt;100</td>
<td>100-150</td>
<td>&gt;150</td>
</tr>
<tr>
<td>Pb (mg/l)</td>
<td>26.37-58.10</td>
<td>44.47+10.94</td>
<td>&lt;250</td>
<td>250-500</td>
<td>&gt;500</td>
</tr>
<tr>
<td>Cu(mg/l)</td>
<td>6.7-155.0</td>
<td>44.8+43.1</td>
<td>&lt;135</td>
<td>135-270</td>
<td>&gt;270</td>
</tr>
<tr>
<td>Ni(mg/l)</td>
<td>40.67-65.60</td>
<td>53.58+7.68</td>
<td>&lt;75</td>
<td>75-150</td>
<td>&gt;150</td>
</tr>
<tr>
<td>Zn(mg/l)</td>
<td>40.1-262.5</td>
<td>127.7+69.7</td>
<td>&lt;300</td>
<td>300-600</td>
<td>&gt;600</td>
</tr>
<tr>
<td>pH</td>
<td>7.65-8.27</td>
<td>8.10+0.21</td>
<td>&lt;5.5</td>
<td>5.5-7.5</td>
<td>&gt;7.5</td>
</tr>
<tr>
<td>EC(uS/cm)</td>
<td>265.3-795.3</td>
<td>534.5+217.1</td>
<td>&lt;400</td>
<td>400-130</td>
<td>&gt;130</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>132.7-509.0</td>
<td>321.6+141.9</td>
<td>&lt;500</td>
<td>500-1500</td>
<td>&gt;1500</td>
</tr>
<tr>
<td>Temp(oC)</td>
<td>16.93-19.03</td>
<td>18.36+0.641</td>
<td>&lt;20</td>
<td>20-30</td>
<td>&gt;30</td>
</tr>
</tbody>
</table>

The results showed that all the soil samples near Nullah sites lie within permissible limit range. The range of Ni in soil samples was 40.67-65.60 and the mean was 53.58. In all the soil samples, the range of Ni lie within permissible range for the growth of plants. The range of Zn was 40.1-262.5. The mean of soil samples was 127.7. The results of Zn showed the same phenomenon that soil near Nullah Lai is suitable for the growth of different vegetation. Perveen et al (2011) discussed that among the heavy metals, Cu, Mn, Pb and Cd were found in excessive concentration in sewage water while Fe, Zn, Cr, and Ni were found in normal range of the national environmental quality standards (NEQS, 2000), continuous use of such water for irrigation over longer period may cause accumulation of Cd, and Pb, up to toxic levels for plant and animal health (Kirkhan, 1983) and (Adhikari et al., 1998).

The range of Pb in all soil samples lie from 26.37-58.10. The mean of all soil samples was 44.47. The results showed that range of Pb in all the soil samples lie within permissible limit. The range of Cu in all soil samples was 6.7-155.0 and the mean was 44.8. The results of Cu showed that all of the soil samples lie within range so soil near Nullah Lai can be used for the vegetation of plants. Batayneh (2008) stated most Pb concentrations for both seasons are higher than the maximum permissible concentration level (MPCL) and recommended (Jordanian Institution for Standards and Metrology (JISM, 2008). (0.01 mg/l) for drinking water. The contamination of soils, sediments, water resources and biota by heavy metals is of major concern, especially in many industrialized countries, because of the toxicity, persistence and bioaccumulative nature of these metals (Ikem et al., 2003). The pH of soil samples was from 7.65-8.27 and the mean was 8. The results of pH showed that all the samples lie in highest range as recommended.

The EC of soil samples was from 265.3-795.3 and the mean of all soil samples was 534.5. The results of all soil samples was in permissible limit range. The range of TDS in all soil samples was 132.7-509.0 and the mean was 321.6. The range of TDS lie within permissible limit. The temperature of all soil samples was 16.93-19.03 and the mean of soil samples was 18.. The temperature of all the soil was in permissible limit range recommended for the growth of vegetation. All of the above results showed that soil near Nullah Lai area is suitable for the growth of vegetation and wild plants, because most of the heavy metals lie within permissible limit recommended for the growth of vegetation.

Relationships between wastewater characteristics and total physico-chemical contents in wastewater samples of Nullah Lai area.
Correlation coefficients (r values) between wastewater characteristics and total physico-chemical contents in wastewater samples of Nullah Lai area is given in Table 4.
The wastewater Cd content had a positive correlation with pH \((r = 0.48)\), Cu \((r = 0.07)\) and Pb \((r = 0.76)\), a highly significant negative correlation with EC \((r = -0.82)\) and TDS \((r = -0.82)\), and negatively correlated with Ni \((r = 0.57)\). The Cd had a highly significant positive correlation with Pb \((r = 0.76)\). The Chromium content in the wastewater had a positive correlation with pH \((r = 0.34)\), Cd \((r = 0.62)\), Pb \((r = 0.58)\) and Zn \((0.04)\), and negatively correlated with EC \((r = -0.54)\), TDS \((r = -0.54)\), Temp \((r = -0.31)\), Cu \((r = -0.09)\), and Ni content \((r = -0.49)\). The Pb content in the wastewater had a positive correlation with pH \((r = 0.50)\), Cu \((r = 0.34)\), and Zn \((r = 0.34)\) and a highly positive correlation with silt content \((r = 0.862)\) and a highly significant negative correlation with EC \((r = -0.63)\), TDS \((r = -0.63)\), Temp \((r = -0.70)\) and Ni \((r = -0.69)\). The Copper content had a positive correlation with pH \((r = 0.10)\) and Zn \((r = 0.15)\) and negative correlation with temperature \((r = -0.36)\) and Ni \((r = -0.54)\). Nickel had a positive correlation with EC \((r = 0.422)\), TDS \((r = 0.330)\) and Temperature \((r = 0.42)\) a significant negative correlation with pH \((r = -0.67)\) and negatively correlated with Zn \((r = -0.49)\).

Zinc had a positive correlation with pH \((r = 0.46)\), a negative correlation with temperature \((r = -0.25)\) and highly significant negative correlation with EC \((r = -0.64)\) and TDS \((r = -0.64)\). The pH had a negative correlation with temperature \((r = -0.11)\) a significant negative correlation with EC \((r = -0.82)\) and TDS \((r = -0.82)\). EC had a positive correlation with temperature \((r = 0.22)\) and highly significant positive correlation with temperature \((r = 0.22)\). TDS had a positive correlation with temperature \((r = 0.22)\).

### Table 4. Correlation coefficients (r values) between wastewater characteristics, total physico-chemical contents in wastewater samples in Nullah Lai area.

<table>
<thead>
<tr>
<th>Water Characteristics</th>
<th>Cd (mg/l)</th>
<th>Cr (mg/l)</th>
<th>Pb (mg/l)</th>
<th>Cu (mg/l)</th>
<th>Ni (mg/l)</th>
<th>Zn (mg/l)</th>
<th>pH</th>
<th>EC (μS/cm)</th>
<th>TDS (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>0.48</td>
<td>0.34</td>
<td>0.50</td>
<td>0.10</td>
<td>-0.67*</td>
<td>0.46</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EC(μS/cm)</td>
<td>-0.82**</td>
<td>-0.54</td>
<td>-0.63*</td>
<td>0.00</td>
<td>0.57</td>
<td>-0.64*</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TDS (mg/l)</td>
<td>-0.82**</td>
<td>-0.54</td>
<td>-0.63*</td>
<td>0.00</td>
<td>0.57</td>
<td>-0.64*</td>
<td>1.00**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Temp(°C)</td>
<td>-0.52</td>
<td>-0.31</td>
<td>-0.70*</td>
<td>-0.36</td>
<td>0.42</td>
<td>-0.25</td>
<td>-</td>
<td>0.22</td>
<td>0.22</td>
</tr>
<tr>
<td>Cd (mg/l)</td>
<td>-</td>
<td>0.62</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cr (mg/l)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pb (mg/l)</td>
<td>0.76**</td>
<td>0.58</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cu (mg/l)</td>
<td>0.07</td>
<td>-0.09</td>
<td>0.34</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ni (mg/l)</td>
<td>-0.57</td>
<td>-0.49</td>
<td>-0.69*</td>
<td>-0.54</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Zn (mg/l)</td>
<td>0.70*</td>
<td>0.04</td>
<td>0.34</td>
<td>0.15</td>
<td>-0.49</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Significant relationship \((p<0.05)\)
**Significant relationship \((p<0.01)\)
Lead of water samples had a highly significant positive correlation with Cr (r = 0.63) and pH content of the soil (r = 0.78), a highly significant negative correlation was observed with EC (r = -0.56), TDS (r = -0.62), a significant negative correlation with Zn (r = -0.45) and a weak negative correlation with Cd (r = -0.15), Pb (r = -0.40), Cu (r = 0.06), Zn (r = 0.31). A highly significant negative correlation was observed with Cd (r = -0.60) and TDS (r = -0.13). Overall, the results showed that water is not able to be used for irrigation purpose. The soil samples in most of the localities showed metal contents within permissible limit range. Islamabad showed high levels of all the parameters. The concentrations of metals and some anions in all the wastewater samples were higher in than values set by WHO for drinking purpose but able to be used for irrigation purpose. The soil samples in most of the localities showed metal contents within permissible limit range. Overall, the results showed that water is not able

The pH of water samples had a significant positive correlation with Ni (r = 0.45) and a positive correlation with Cd (r = 0.12), Cr (r = 0.29), Pb (r = 0.18), Ph (r = 0.27), temperature (r = 0.37). A negative correlation was observed with Cu (r = -0.20), Zn (r = -0.10), EC (r = -0.43), TDS (r = -0.13).

TDS of wastewater samples had a highly significant positive correlation with Cu (r = 0.47), EC (r = 0.59), a positive correlation with Pb (r = 0.06), Zn (r = 0.43), TDS (r = 0.31). A highly significant negative correlation was observed with Cr (r = -0.45) and pH (r = -0.46) of soil samples. TDS had a negative correlation with Cd (r = -0.31) and Ni (r = -0.43) of soil contents.

EC had a highly significant positive correlation with Cu (r = 0.47) and EC (r = 0.59), a positive correlation with Pb (r = 0.06), Zn (r = 0.43), TDS (r = 0.31). A highly significant negative correlation was observed with Cr (r = -0.45) and pH (r = -0.46), A weak negative correlation was observed with Cd (r = -0.31), Ni (r = -0.43) and Temperature (r = -0.43).

**CONCLUSION**

From this research, it is concluded that the physicochemical parameters monitored in Nullah Lai water and in the vicinity soil samples of Rawalpindi and Islamabad showed high levels of all the parameters. The concentrations of metals and some anions in all the wastewater samples were higher in than values set by WHO for drinking purpose but able to be used for irrigation purpose. The soil samples in most of the localities showed metal contents within permissible limit range. Overall, the results showed that water is not able
to be use for drinking purpose but can be used for irrigation purpose. It has been observed that Nullah Lai receives a lot of wastes from industrial, agricultural and domestic sources. It serves as the source of drinking water, fish and irrigation for the various communities settling along its banks and catchment area. The uncontrolled consumption of poor quality drain water may be dangerous for human health. There is no prudent wastewater collection and treatment system due to which the problem of disposal of wastewater will increase manifolds in future. Mismanagement of wastewater is a potent threat to drinking water system. Therefore, there is a dire need of construction of wastewater treatment plants in order to achieve water efficiency. With more industries discharging their effluents into the drain, the prospects of a greater pollution is high which also increase the risk to public health. Therefore, there is a need to constantly monitor the concentration levels of heavy metals in the drain as well as mounting comprehensive conservation efforts by relevant organizations. There is an increasing awareness among the people to maintain the wastewater. The values of correlation coefficients and their significance levels will help in selecting the proper treatments to minimize the contaminations of wastewater of Nullah Lai.

**RECOMMENDATIONS**

On the basis of present findings following recommendations are proposed:

- To clean up the Nullah lai, sewage and industrial effluents should be treated before they are discharged into the drain.
- The Nullah Lai water quality appears to be well at some places within potential reuse schemes excluding potable use. The collection of drain water into a single reservoir after every three kilometers will act as a sedimentation and equalization tank. This can be accomplished by utilizing the drainage network by blocking the discharge end, and thus converting the network to a sedimentation and temporary storage reservoir. In addition, the application of $\text{H}_2\text{O}_2$ inside the network to maintain the aerobic and disinfected environment is recommended. The supernatant can then be collected, disinfected with chlorine, and stored in long-term retention reservoirs. This stored water can then be used for irrigation and animal drinking.
- Alternate sources of drinking water for cattle should be provided in those areas where canal water is not available.
- Further studies are needed to estimate trace elements in soils, plants, animal blood, and human blood samples of different population groups of the area.
- Further research is needed to characterize the organic compounds in drain water.
- It is important that bacteriological assessment of water from these different sites be carried out to be sure if the water is safe for drinking and other domestic applications.
- As an ultimate solution one has to provide the city of Rawalpindi with a proper and adequate wastewater collection system capable of handling the entire waste that is being generated from the city presently and also in coming days.
- There should be a state of the art Waste Water Treatment Plant in Rawalpindi city to protect the natural streams for direct wastewater contamination. The existing solid waste management practices are not satisfactory and are causing environmental problems. It is therefore, recommended that a comprehensive solid waste management system be adopted with provisioning of state of the art sanitary land fill site.

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**REFERENCES**


