Characterization of Drain Surface Water: Environmental Profile, Degradation Level and Geo-statistic Monitoring

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Abstract
The physico-chemical characterization of the surface water. Samples was carried out collected from nine sampling points of drain passing by the territory of Hafizabad city, Punjab, Pakistan. The water of drain is used by farmers for irrigation purposes in nearby agricultural fields. Twenty water quality parameters were evaluated in three turns and the results obtained were compared with the National Environmental Quality Standards (NEQS) municipal and industrial effluents prescribed limits. The highly significant difference (p<0.01) was recorded for the content of phenols, carbonyl compounds, cyanides, dissolved oxygen, biological oxygen demand, total soluble salts, total dissolved salts, nitrates and sulphates, whereas, the concentration of magnesium, potassium and oil & grease differed significantly (p<0.05) with respect to the sampling points on average basis. Non-significant difference (p>0.05) was noted for temperature, pH, electrical conductivity, hardness, calcium, sodium, chemical oxygen demand and chloride among water samples from different sampling points. Furthermore, the experimental results of different water quality parameters studied at nine sampling points of the drain were used and interpolated in ArcGIS 9.3 environment system using kriging techniques to obtain calculated values for the remaining locations of the Drain.

Keywords: Degradation; Drain; Kriging; Monitoring.

Introduction
During the last few decades shortage of water has become a critical problem in Pakistan as well as in several other developing countries. In Pakistan, both rural and urban populations are facing severe shortage of water due to continuous increase of pollution and agriculture expansion. As result, in many areas, people and farmers use polluted water for drinking and irrigation purposes [1]. In Pakistan, due to lack of proper facilities of waste disposal just 1% of the wastewater is treated before being discharged into water bodies, thus rendering water unsuitable for drinking, industrial, agricultural and recreation purposes etc. [2]. Moreover, water pollution and accumulation of metal in freshwater ecosystems has become a global problem both in developing and developed countries. Accumulation of metals and various diseases in aquatic organisms without producing visible signs of warning for the potential consumer are linked to the water. The polluted water largely influence human, plants and aquatic life, moreover certain pollutants enters into food chain and ultimately reach at higher trophic level such as human [3,4]. It is therefore recommended that

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more strict methods of waste effluent management should be adopted to reduce the inputs of pollutants into the water bodies to preserve ecosystem and save human beings from various water borne diseases [5]. For this purpose modern geostatistic techniques have been developed for large scale environmental monitoring and allow spatial visualization of the contaminated areas by mapping. An interpolation technique known as kriging is used extensively for this purpose. Prediction maps produced by kriging interpolation provided useful information for hazard assessment that can help decision makers in taking appropriate actions to protect public health [6].

Many researchers focused to investigate the drivers responsible for water pollution, types and quantification of pollutants and their hazardous impact on floral and faunal populations [7]. Keeping in view the fact that domestic, industrial, commercial and agricultural sources are the key drivers of water pollution in Pakistan, hence, the investigation of physical, chemical and biological characteristics of water can be helpful to saving different water resources from further degradation and contamination. The farmers use the under study drain water for irrigation in nearby agricultural fields. Therefore the present study was designed to check the level of contaminants and pollutants in water of the drain passing by the territory of district Hafizabad, Punjab, Pakistan. The city is recognized worldwide for its high quality rice products.

**Materials and Methods**

To establish Environmental profile of drain passing through the surrounding areas of Hafizabad city Pakistan and to investigate its pollution level, based on the initial survey, nine sampling stations were selected for the collection of water samples. These sampling stations are shown in the (Fig.1).

![Location Map of Hafizabad](image)

*Figure 1. Location map showing the sampling points*
Sample Collection and Preservation

On each sampling occasion, water samples from all the nine points were collected on the same day with a little time difference. Spot or grab sampling and composite sampling procedures were employed. After sample collection sample preservation is important for retarding biological action, hydrolysis of chemical compounds and complexes and reduction of volatility of constituents. Sample preservation was carried out according to the “Standard Methods for the Examination of Water and Wastewater” [8].

Physico-chemical analysis

A glass thermometer was used to measure temperature of water samples collected from different sampling points of drain. The pH, electrical conductivity and total dissolved solid (TDS) of water samples were measured using handheld pH/electrical conductivity (EC)/TDS meter (Hanna Instruments, model HI 9812). Calcium & hardness was determined by EDTA Titrimetric method, while, the magnesium concentration was determined from the EDTA calcium and hardness titration. For sodium and potassium determination flame photometer (Digital Flame Analyzer Model No. FGA 350) was used. Soxhelt apparatus was used for the extraction and estimation of oil and grease (mg/l) using n-hexane as extraction solvent. Carbonyl compounds and cyanides were estimated gravimetrically, whereas, phenols were determined by direct photometric method. Dissolved oxygen (DO) meter (Hanna Instruments model HI 9142) was used on defined sampling sites for the measurement of DO of water samples. Reactor digestion method was used for the determination of chemical oxygen demand (COD) [9], while biological oxygen demand (BOD) was measured by standard BOD 5 method [13]. Suspended solids, sulphate and nitrates were determined by photometric method (HACH Water Analysis Handbook 2002), attenuated radiation method (HACH Water Analysis Handbook 2002), the SPADNS method (HACH Water Analysis Handbook 2002), SulphaVer 4 method (HACH Water Analysis Handbook 2002) and cadmium reduction method (HACH Water Analysis Handbook 2002) using HACH spectrophotometer DR/20/0, respectively. For chloride determination, argentometric titration method was used [10].

Interpolation studies and statistical analysis

The experimental results of different quality parameters studied at nine sampling points of the drain were used and interpolated in GIS environment using kriging techniques to obtain calculated values for the remaining locations of the Drain. It was performed using ArcGIS 9.3 system. The sampling points of under study drain were compared by analysis of variance (ANOVA) using IBM SPSS Statistics (Version 20.0).

Results and Discussions

Different quality parameters of surface water samples collected from nine defined sampling points of drain were analyzed to assess the degradation level of drain surface water. The results were compared with National Environmental Quality Standards (NEQS) guideline data for municipal and industrial effluents.

The discharge of municipal sewage to streams can change the conductivity of water bodies as sewage comprising chloride, phosphate, nitrate and oil spill lowers the conductivity. High electrical conductivity indicates a larger quantity of dissolved mineral salts [14]. The average Electrical
Conductivity (EC) values ranged from 1475 to 1546 µ siemens/cm. However, the acceptable limit of EC is 1000 µ siemens/cm as per NEQS; hence the present study indicated higher level of electrical conductivity compared to recommended level, which may be due to the heavy sewage dumping and high concentration of ionic constitutions [15]. The hard water has no known impacts on health of organisms, but still is unsuitable for domestic uses [16]. The hardness of water is mainly due to presence of magnesium, calcium and chlorides in the domestic wastes [17]. Water hardness ranged from 194 to 216 ppm. Such kind of variation in hardness are also reported by Hasan et al., [18] while investigating water quality of river Toi in Khyber Pakhtunkhwa.

The municipal agencies analyze trace minerals in wastewater samples to ensure water cleanliness and public health safety [19]. The rock weathering is considered a key source of trace minerals (e.g. Ca, Mg, Na and K), rain water further exaggerate the accumulation of trace minerals in water bodies [20]. The present study indicated that Calcium, Magnesium, Potassium and Sodium concentrations ranged from 71.8 to 81.6, 40.7 to 54.4, 17.9 to 22.3 and 10.7 to 12.5 ppm, respectively, among the selected sampling points. Analysis of variance revealed that magnesium and potassium varied significantly (p<0.05), whereas sodium and calcium varied non-significantly (p>0.05) at different sampling points of drain (Table 1). The high concentration of oil and grease in wastewater have adverse impacts on living organisms like inhibition of animal and plant growth; carcinogenic and mutagenic to human being and imbalance of ecosystem [21]. Moreover, the higher concentration of oil and grease generally forms a layer over the surface of water, reduces light penetration and photosynthesis [22]. The oil and grease contents of drain water ranged from 14.8 to 20.0 mg/l. The recorded values of oil and grease at all the sampling points were beyond the NEQS limiting value (10 mg/l) for oil and grease, indicating a higher level of oil and grease pollution in surface water of drain in district Hafizabad.

The degradation of natural substance, agricultural practices and industrial activities are the major source of phenolic compounds in the water bodies. Moreover, chlorination of phenol-containing water can lead to the formation of chlorophenols, which have unpleasant taste and are toxic as well [23]. In understudy drain the estimated phenolic and carbonyl compounds in the surface water samples ranged from 3.0 to 6.0 and 0.6 to 0.9 ppm, respectively. Analysis of variance revealed highly significant (p<0.01), difference for phenolic and carbonyl compounds at among sampling points of under study drain (Table 1).

Cyanide compounds are strictly regulated world over because of their extreme toxicity. Furthermore due to cyanide toxic effects, effluents comprising cyanide compounds cannot be discharged without detoxification into the environment [24]. Cyanide contents varied significantly (p<0.01) at different sampling points of understudy drain, ranging between 0.01 to 0.03 ppm. The permissible limit for cyanide is 1 mg/l according to NEQS.

The DO is a key factor to determine the quality of water, and is imperative for aquatic life. The present study revealed highly significant (p<0.01) difference for DO among different sampling points of drain. The DO level in drain water ranged from 2.5 to 4.7 ppm. The lower amount of DO in drain water might be due to increased sewage waste inclusion in drain water. The determination of BOD is an essential test to evaluate the relative oxygen requirements of wastewaters, effluents and polluted waters [14]. COD is often used as a measurement of pollutants in natural and waste waters and to assess the strength of waste, such as sewage and industrial effluent waters [25]. Whereas, the measure of COD determines the quantity of organic matter found in water therefore it indirectly indicates the organic pollution in surface water [26]. In understudy drain BOD varied significantly (p<0.05) whereas COD varied non-significantly (p>0.05) among different sampling points of drain. While the (BOD)5 and COD values ranged from 31.0 to 45.0 and 55.0 to 70.0 ppm in drain water, respectively. The NEQS guideline values for BOD and COD are 80 and 150 ppm, respectively. Interestingly BOD and COD values in drain water were found below NEQS limiting values for these parameters. However continuous increase in the values of these parameters is alarming, which intimates that urgent management should be taken to minimize the pollution causing agents.
Biodiversity holding capacity of water decreases as the TSS rises in water. Moreover light penetration also reduce due to TSS, consequently minimize the process of photosynthesis in water body [22]. Similarly TDS in water bodies enhance the biological and chemical oxygen demand ultimately reducing the level of dissolved oxygen in water [25]. The guideline values as per NEQS for TSS and TDS are 200 and 3500 mg/l, respectively. The TSS and TDS in the surface water at sampling points i.e. 1-9 of drain were found to be varied from 243 to 296 and 1022 to 1248 mg/l, respectively. The higher level of both TSS and TDS in water samples is mainly due to the excessive discharge of domestic and industrial wastes [4].

The agricultural runoff and wastewater from industries and rocks comprising of chlorides are the main sources of chlorides in surface water [27]. The sources of sulphates (SO\(^{-4}\)) in the environment are both natural and anthropogenic such as industrial and domestic. The impact of higher level of sulphates in water bodies causes diarrhea and laxative effects [28]. Anaerobic rotting and microbial decay of plants and animals are responsible for nitrogen content in water [29]. Dissolved salts i.e. chlorides, nitrates and sulphates were estimated in the understudy surface water samples and were revealed to be ranged from 297 to 324, 0.10 to 0.30 and 68 to 186 ppm, respectively. The NEQS prescribed limit for chloride is 1000 mg/l. The defined NEQS limiting value for sulphates in waste water is 600 mg/l.

<table>
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<th>Parameter</th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>Min - Max</th>
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<td><strong>Temperature °C</strong></td>
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<td>0.640</td>
<td>0.831</td>
<td>27.0 - 28.5</td>
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<td>Within Groups</td>
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<td>18</td>
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<td></td>
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<tr>
<td><strong>pH</strong></td>
<td>Between Groups</td>
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<td>8</td>
<td>0.039</td>
<td>0.637</td>
<td>7.85 - 8.24</td>
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<td>Within Groups</td>
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<td>0.061</td>
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<td><strong>Electrical Conductivity (µ siemens/cm)</strong></td>
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<td>1788.759</td>
<td>1.690</td>
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<td>Within Groups</td>
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<td>1058.593</td>
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<td><strong>Hardness (ppm)</strong></td>
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<td>8</td>
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<td>1.661</td>
<td>194 - 216</td>
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<td><strong>Calcium (ppm)</strong></td>
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<td>1.363</td>
<td>1.246</td>
<td>10.7 - 12.5</td>
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Sampling of the surface water was carried out from nine sampling points along the stretch of drain passing through the territory of Hafizabad city. The procured results were then used to find out water quality along the whole drain i.e. from the sites other than the defined sampling points. The experimental results were interpolated in GIS environment using kriging techniques (Fig 2).
Conclusion

The present investigation reveals that understudy drain contains various pollutants, which pollute the quality of water. These pollutants mainly enter into drain water by domestic and industrial effluents, and if this addition of waste remains constant, then in near future this drain water will be completely unfit for the use of agricultural purposes as well as a threat to ecosystem. Therefore urgent measures are needed to control pollution level in small water bodies. Although many parameters are in range of NEQS guideline values still, there is considerable need for better understanding of these small water bodies so that they can be managed in an eco-friendly manner.

References