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Physico-chemical Investigation of Quality Characterization of Peshawar City Effluents

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Abstract: Water is an, important component for life and it needs to be assessed at all stages in order to ascertain its safe usage. Keeping in view the importance of water, the waste water samples were collected, from major waste water drains (i.e. Shahi Khatta, Muhammad Zai and Hazar Khwani drain) of Peshawar City and were assessed for its quality characterization. Total 24 samples of water on hourly basis collected from each site were analyzed for physicochemical parameters like pH, Color, TSS, Total, TDS, COD, BOD, Oil and Grease, SO_{4-}, S^{-2}, $NH_3$and Cl^-. The results showed that concentrations of TSS, COD, BOD, Sulphate and sulfide were well above the permissible level of the National Environmental Quality Standards of Pakistan and needs treatment before its discharge into the river water. Ways and means of wastewater reductions needs to be identified to reduce the cost of waste water treatment.

Key words: Chemical Oxygen Demand, Biological Oxygen Demand, Physico-chemical parameters, Sulphide, Effluent of Peshawar City

INTRODUCTION

Most important substance for living things is water and without water life on the earth is not possible. Out of the total quantity of water, approximately 1.4 trillion cubic meters is present on earth (F. Parveen et al. 2007). It is the most important factor for life used for both domestic and industrial purposes. Of the total water on lithosphere, only 3% is freshwater. Of which only 0.01% of this freshwater is available for human consumption (D. Hinrichsen, H. Tacio, 2002). Unluckily even this small proportion of water is also under great emphasis due to rapidly increasing population, unchecked urbanization and more than enough consumption of water in industry and for irrigation purposes. In Pakistan like developing countries, the water consumption and demand for its supply is increasing due to increase in population, farming and establishment of new industries and the problem is further exacerbated due to improper management and unavailability of skilled professionals and financial limitations (PCRWR. Annual Report 2005–2006). With the rapid development in agriculture, mining, urbanization, and industrialization activities, the river gets contaminated water. The water quality and human health are closely related. The waste domestic uses from each house in the area along with the effluent of cottage industries is disposed off into the main drains and gutters collecting the wastes from the area enter into the rivers, resulting the deterioration of the water quality and affecting health of the community in one way or the other (B.S. Ashok Kumar et al., 2010).

The water consumption demand during the last decade has been increased almost two fold as the people migrated due to troubles in the adjacent tribal belt of Peshawar. Besides, many industries and commercial

activities in and around Peshawar city are not only utilizing the fresh ground water but also throwing their waste water untreated into river Kabul.

Rivers are getting contaminated due to waste disposing into them. Waste consists of both liquid waste and solid waste, disposed off by residents of the area, commercial sectors, industries, agriculture can encompass an enormous amount of potential toxic contaminants of variable concentrations (APHA, 1998). Municipal wastewater has a wide spectrum of contaminants as a result of mixing of wastewater from different sources like residences, chemical based institutions, hospitals and industrial setups (APHA, 1998). Besides this, as rainfall runs over the roofs of the covered areas of the buildings and the ground, it may take along various pollutants consisting of soil particles, sediments, heavy metals, compounds of organic nature, grease, oils, and animal waste (FWPCA, 1968). Consequently, when these effluents join the water body, it changes the physicochemical behavior of water, making it uncertain for safe use. Since bacteria and the required nutrients present in almost all natural waterways will initiate biochemical reactions which are known as BOD and COD in laboratory (G. Tchobanoglous et al. 2003). Both COD and BOD analysis are relative oxygen-deficiency effects of waste contaminant. Both measure the pollution effect i.e. BOD counts for the oxygen demand of biodegradable contaminants and demand for oxidizable contaminants is known and measured as COD. Wastewater disposal from an industry is a costly and difficult problem (C. N. Sawyer). Physically, water is described by its colour, odour, solid content and water content (Massoud Tajrishy, Ahmad Abrishamchi. 2005). Solids in dissolved form that are approximately 70%; whereas, 30% solids in suspended form. The Solids which are dissolved forms can be settled down by biological and chemical practices. According to physical phenomena, the solids in suspended form result in the formation of sludge dumps and oxygen deficient environment when discharged into the surrounding environment (S.K. Maiti, 2004). Wastewater is chemically, comprised of inorganic and organic constituents and dissolved gases. Organic constituents may contain proteins, fats, oils carbohydrates, greases, surfactants, phenols and pesticides, etc. (G. Tchobanoglous et al. 2003; S.K. Maiti, 2004). Treatment of potable water can become weighed down if water body is seriously polluted by microorganisms. A variety of microorganism have an undesirable effect on human physical condition. Several diseases related to wastewater exposure are relatively most common (WHO, 1999). The purpose of this research study was to check the physical as well as chemical aspects of the waste effluents of Peshawar city and to find the degree of pollution in them.

Irrigation of the fields for agricultural purposes with wastewater is a common practice in the developing world and a lot of research articles are being available on soils irrigated with wastewater polluted by heavy metals (F. Mapanda et al., 2005; R.K. Rattan and et al., 2005; S. E. Rothenberg and et al., 2007).

Excessive addition of pollutants to agricultural lands through wastewater irrigation will not only answer in soil contagion, but will also result in the elevated pollutants absorption by crops, and consequently affect foodstuff quality and security (M. Muchuweti et al., 2006). In Pakistan, about 26% of national vegetable crops is irrigated with wastewater. Increase in population in turn results in increased use of freshwater for domestic purposes, made the basis for increasing trend of irrigating fields and crops with wastewater. Around 70% of the water utilized in cities is refused as wastewater and its volume has increased with increase in population and economic development (F. Khan et al., 2015)

At a global scale, wastewater reuse by irrigation on land is widely practiced, particularly in arid areas. Concerns about wastewater irrigation relate to groundwater pollution and deterioration of the irrigated soil resulting from the accumulation of wastewater-born metals and organic pollutants (E. Richter et al., 2015)

This study was designed to look into the quality of wastewater by examining the level of COD, BOD, Color, Grease and Oil content, Total Phosphorus, Total suspended solids and total dissolved solids, Ammonia and Sulphide in district Peshawar wastewater. However, a keen look on pollutants uptake by food crops, absorption, their health effects coupled with soils irrigated by wastewater is still needed.

Results and Discussion

pH

pH Measurement in chemistry of water is one of the most significant and commonly used test (Sorenson, S. 1909). If somebody wish to know the life sustainability effect of pH change, he can do so by changing the pH of the environment of the species found mostly in freshwater to acidic conditions. Salmon Population goes on decreasing if pH is below 5.0, for perch pH 6.0 is feasible but not below this value while for eels, feasible pH range for its sustainability is 5.5 and it will have slight life chances below pH 5.0. Mostly metals solubility increases by decreasing pH. This property of metal dissolution upon decreased pH is of great concern if piping systems are made of lead for household water provisions which results in water acidification. The dissolution of minerals e.g. as dolomite and limestone through water will become much rapid at reduced pH (Roger N. Reeve., 2002). In the present study, pH of water samples was within the PNEQS limit. It ranges between 6.5 to 8.5. The average pH of Shahi Khatta was 7.19, Muhammad Zai drain was 7.44 and Hazar Khwani drain was 6.82. From the pH point of view, the effluent does not have a negative impact on the quality of receiving water.

Color

Very slight turbidity makes the color i.e. apparent much higher than true color. This is the reason that turbidity should always be removed before examining true color by taking multiple readings of various color distinguishing filters (A.G. Knight,1951) or it can be done by doing multiple measurements through differential approach of scattering (I. Jullander et al., 1950), as water color value depends strictly on pH and increases with increased water pH. In the present study, the water was very turbid. It was 75, 78 and 83 TCU at Shahi Khatta, Muhammad Zai and Bare Gate respectively. The color at all the three points was well above the permissible level of Pak NEQS, which is 50 TCU.

Total Suspended Solids (TSS)

In Shahi Khatta Drain, TSS are 174.00 mg/l, Muhammad Zai drian 157.00 mg/l and Hazar Khwani drain 182.00 mg/l (Table-1). It has been reported (G.D. Agarwal et al.,1996) that the deterioration of water quality is mainly due to the amount of the TDS present in it. The high amount of TDS was observed into the sewage water samples collected from the sampling point at Hazar Khwani drain. It was observed during the sampling, that residents living on both side of the drains are also putting their house hold solid waste into these drains.

Total Dissolved Solids (TDS)

The high contents of total suspended solids as well as TDS are mainly due to the discharge of commercial and domestic solid waste. The total dissolved solids at sampling points Shahi Khatta was 3720.00 mg/l at Muhammad Zai Drai 2980.00 mg/l and at Hazar Khwani Drain point, it was 3650.00 mg/l. High level of TDS and TSS not only causing problems and fatal for aquatic organism but its sedimentation would cause overflowing and flooding.

Chemical Oxygen Demand (COD)

It is also an important marker of water contamination. It shows the amount of oxygen used for the decomposition of chemical substances. The concentration of COD at Shahi Khatta Drain was 560 mg/l, Muhammad Zai Drain 544 mg/l and that of Hazar Khwani Effluents was 480.00 mg/l. The concentrations of COD at all points were well above the permissible limits of Pakistan NEQS (150 mg/L). This sewerage water in some areas are also used for irrigation purposes and therefore strong vigilance is required to control the COD content of waste water which will destroy our flora and fauna.

Biochemical Oxygen Demand (BOD)

During decomposition of organic matter, the quantity of oxygen consumed is called BOD. It determines the relative oxygen demand/requirement by wastewaters. Higher amount of BOD, means high quantity of organic load is present in waste water. The level of BOD (Table-1) at Shahi Khatta waste water was 136.00 mg/l, Muhammad Zai Drain 140.00 mg/l and at Hazar Khwani it was 175.00 mg/l. The concentration at all the sampling points were well above Pak. NEQS limits i.e. 80.00 mg/l. High quantity of BOD is fatal for aquatic life and the wastewater needs to be treated before its discharge to the river Kabul.

Oil and Grease

1) Discharging Oil and grease in wastewater and treated waste matter often results in surface films and deposition on shoreline triggering degradation of environment. To know about the amount of oil and grease in any wastewater is useful for operation and designing of waste handling plants and may also solve certain problems in waste management. Without any special modification for production of certain products, oil and grease comprise mostly fatty matter from vegetable origin or it may be from animal sources or petroleum based hydrocarbons (APHA, AWWA, WEF, 22nd Edition, 2012). From the data in table-1, it can be seen that in Shahi Khatta effluent, 2.50 mg/l oil and grease contents have been found and in Muhammad Zai Drain, it was 2.91 mg/l while in Hazar Khwani effluent, the content of oil and grease was 1.92 mg/l. The concentration although was within the permissible limits of Pak NEQS, during design of the waste water treatment, it is recommended that special attention is required, as in future the concentration of oil and grease may increase due to enhanced commercial activities in the region.

Sulphate (SO_4^{-2})

In nature, it is available extensively and in natural water, it has been found in quantities ranging from a small amount to thousands of mg/L. Sulfate concentration in drinking water of Peshawar city is comparatively high because excessive amount of underground water is being pumped out for domestic and commercial activities. The high contents of sulfate in water is mainly due to pyritic nature of the inner core of the earth. From the results in Table-2, it is observed that Shahi Khatta Drain has sulphate concentration 353.00 mg/L, and Muhammad Zai Drain has 92.23 mg/L while Hazar Khwani Drain has 145.00 mg/L sulphate concentration.

Sulfide S_2^-

The pungent smell of waste water is an indicator that sulfide is present in the water. As for as wastewater is concerned, it comes to some extent from the decay of organic material, to some extent from industrial effluents but widely from reducing sulfate by bacterial community. H_2S emitted into the air from wastewater containing sulfide results in rotten smell causing irritations. The quantity of H_2S in waste effluents at Shahi Khatta is 7.80 mg/l, 10.50 mg/l in Muhammad Zai Drain and 5.70 mg/l in Hazar Khwani drain. H_2S in dissolved form is poisonous to aquatic life and fish [18]. Sulfide directly and indirectly may cause severe corrosion of concrete sewers, metals for the reason that it gets oxidized to H_2SO_4 on the walls of the pipes biologically. The corroded metal pipes were observed during survey and sample collection at all the three sampling sites.

Ammonia (NH3)

The waste organic material present can take away oxygen from water through the process of oxidation. Even though this practice can be written and considered as chemical response but actually it is microbiological course of action known as aerobic decomposition which transfers the main elements present in plant matter (C.H.N.S) in carbon dioxide (CO_2), water H_2O, nitrates NO_3 and sulphates SO_4, correspondingly. Astonishingly if there is no oxygen organic components, decomposition will result in reduction instead of oxidation by the process called anaerobic decomposition and the products formed will be CH_4, NH_3, and H_2S.

In the present study, ammonia is present, which indicates that anaerobic decomposition has been occurred and the organic substances present in water has consumed the existing oxygen to a greater extent.

The table -1 shows that the concentration of ammonia is 10.29 mg/l, 11.51 mg/l and 7.82 mg/l at Shahi Khatta, Muhammad Zai and Hazar Khwani drains. Although, the concentrations of ammonia at all three sampling points are within the permissible limit of Pak NEQS; however, the presence of such quantity of ammonia is alarming signal for the waste water treatment experts.

Chloride (Cl^-)

The higher concentration of chloride in wastewater may be due to sodium chloride (NaCl) which is a common item of diet and goes unaffected through the process of digestion occurring in human body system. If there is sea coastal water under consideration chloride may possibly be present in greater amount because of seepage of saline water in the sewerage scheme. It may also be increased by industrial effluents (APHA, AWWA, WEF, 22nd Edition, 2012). From the results it can be seen that chloride in Shahi Khatta effluents is 143.42mg/L while

in Muhammad Zai Drain it is 184.79 mg/L and 520.00 mg/L in Hazar Khwani drain. Presently, the chloride concentration is within the Pak NEQS limit; however, it has been reported that elevated chloride contents could destroy pipe lines made of metals and similarly, it may disrupt new growing flora (APHA, AWWA, WEF, 22nd Edition, 2012).

Conclusion

From the current studies, it is evident that the waste water of the three drains have higher (Fig1) TSS, COD, BOD and in (Fig 2), sulfide concentrations are higher than the permissible level of Pakistan National Environmental Quality Standards. Similarly, the sulfate level is higher (Fig 2) at Shahi Khatta drain and however in the other two drains, they are within the permissible limits. The remaining analyzed parameters are within the limits; however, at this concentration it may also cause triggering effect. The higher concentrations of BOD and COD affect the aquatic flora and fauna and must be treated before its discharge into the Shah Alam River, from where it finds its way into River Kabul. If River Kabul receives continuously the public and industrial effluents, which is watering most of the basin, in future there are greater chances that with the establishment of new industrial zones, as proposed by the Govt. in Peshawar, Nowshera and Swat, the aquifer system will be polluted to a greater amount. The problem of waste water is so huge that the government and the general public will have to play their role for its control. e.g. the responsibility of throwing domestic and municipal waste is not only lye on the shoulder of the Government but the residents have to play their role of not dumping the waste into waste water drain. Awareness raising programs regarding solid waste management, control of excess use of water for domestic purposes, solid waste and less use of plastic shopping bags should be launched both on print and electronic media. The government of Khyber Pukhtun Khwa has planned to treat the municipal waste water; however, it is also suggested that the programs should also be launched to recharge the already depleted under ground water reservoirs of Peshawar City as the water table of the city is going deeper and deeper.

Experimental

Twenty-four waste water samples were collected from two major waste water outlets of the Peshawar City i.e. Shahi Khatta Drain, Muhammad Zai Drain and Hazar Khwani Drain. The samples were shifted to Laboratory by applying standard methods of sampling storage and transportation techniques (APHA, AWWA, WEF, 22nd Edition, 2012).

For chemical parameters such as pH, color, TDS, TSS, BOD, COD, NH_3, Oil and Grease, SO_4, S_2^-, and Cl^- standard procedures of sample collection and transportation were applied. Though microorganisms may reduce SO_4^{2-} to S^{2-} in the presence of certain organic matter, but this problem could no more be the problem by storing the samples at 4^0C (APHA, AWWA, WEF, 22nd Edition, 2012).

The instruments, pH meter and TDS meter were used for hydrogen ion concentration i.e. pH and TDS in that order. Total Suspended solids were determined using filtration method. COD was determined using COD Merck reaction Vials and COD colorimeter. BOD_5 was determined using BOD_5 Hach Incubator for five days.

Sulphate (SO_4^{2-}), Sulphide, and Ammonia were determined using UV-Visible spectrophotometer U-800 Hitachi Japan. Estimation of chloride (Cl^-) was determined using standard argentometric method.

All glassware for the analysis were cleaned cautiously with nitric acid used for the analyses followed by careful rinsing with double distilled water before use. Reagents used in the study were of analytical grade. Distilled water used was doubly distilled all over the study by the standard procedures (APHA, AWWA, WEF, 22nd Edition, 2012).

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Table-1: Physicochemical analysis of waste water samples

Sr. No.	Parameters	Method No.	Units	ShahiKhatta Drain	Muhammad Zai Drain	HazarKhwani Drain	Pak NEQS
1.	pH	4500-H^+.B	-	7.19	7.44	6.82	6.50 – 8.50
2.	Color	2120 B.	TCU	75.00	78.00	83.00	50
3.	Total Suspended Solids (TSS)	2540. D	mg/L	174.00	157.33	182.00	150.00
4.	Total Dissolved Solids (TDS)	2540. C	mg/L	3720.00	2980.00	3650.00	3500.00
5.	Chemical oxygen Demand (COD)	5220 C.	mg/L	544.00	560.00	480.00	150.00
6.	Biochemical Oxygen Demand (BOD)	5210. B	mg/L	136.00	140.00	175.00	80.00
7.	Oil and Grease	5220 B	mg/L	2.50	2.91	1.92	10.00
8.	Sulfate as SO_4	4500-SO_4 E	mg/L	353.00	92.23	145.00	250.00
9.	Sulfide as S^{-2}	4500-S^{2-} F.	mg/L	7.80	10.50	5.70	1.00
10.	Ammonia as NH_3	4500- NH_3 – G	mg/L	10.29	11.51	7.82	40.00
11.	Chloride as Cl	4500 CB.	mg/L	143.42	184.79	520.00	1000.00

Figure-1: Physicochemical analysis of waste water samples

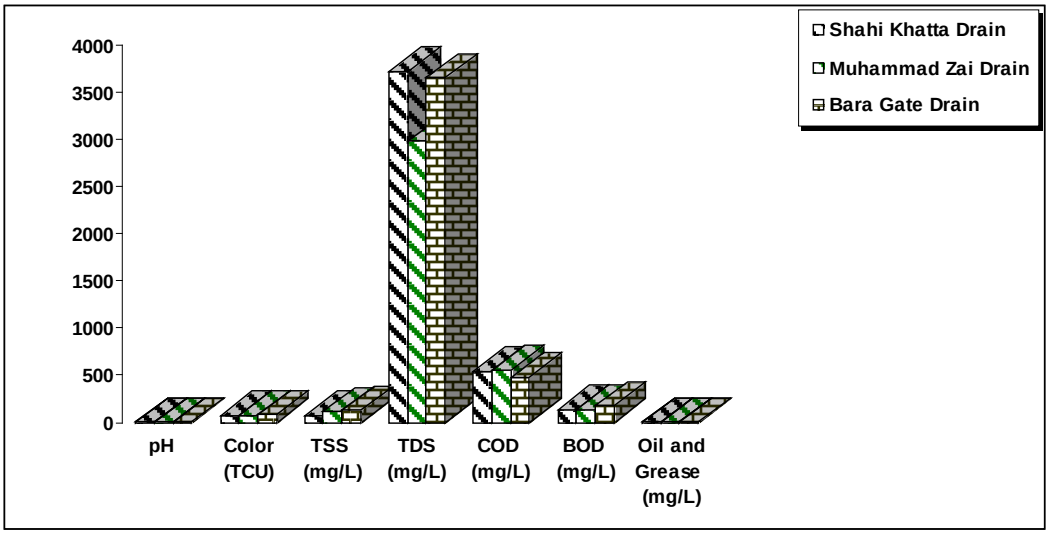

Figure-2: Physicochemical analysis of waste water samples