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Assessment of Waste Water Treatment Plant Efficiency through Physico-Chemical Analysis: A Case Study of I-9 Waste Water Treatment Plant, Islamabad, Pakistan

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Abstract: This study was conducted at I-9 treatment plant, Islamabad to analyze the physicochemical assessment of various parameters and heavy metals concentrations in wastewater and to check the wastewater treatment plant efficiency. Therefore composite wastewater samples were collected from influent, effluent and external streams. Their results were compared with Maximum permissible limits (MPL) of Pakistan Environmental Protection Agency (Pak-EPA). The results of influent, effluent and external stream of wastewater samples are: pH ranged from 6.2 to 6.9, 6.4 to 6.9 and 6.8, EC ranged from 840 to 1250, 830 to 930 and 700 to 890 (μS/cm), Total dissolved solids ranged from 570 to 850, 570 to 630 and 480 to 600 mg/l, total suspended solids ranged from 0.062 to 0.09, 0.008 to 0.42 and 0.068 to 0.069 mg/l, Fluoride ranged from 0.4 to 4.7, 0.8 to 3.5, 1.2 to 2.9 mg/l, Chloride ranged from 48 to 180, 56 to 71 and 44 to 55 mg/l, respectively. Heavy metal concentrations were analyzed by using Atomic Absorption Spectroscopy (AAS) and were found that iron ranged from 0.16 to 2.94, 0.75 to 2.055 and 2.673 to 3.374 mg/l and manganese ranged from 0.193 to 0.579, 0.1 to 0.861 and 0.407 to 0.85 mg/l. Similarly, zinc ranged from 1.9 to 2.7, 1.8 to 2.5 and 2.3 to 2.8 mg/l and Ni ranged from 1.19 to 1.66, 1.15 to 1.56 and 1.11 to 1.21 mg/l. Likewise, lead ranged from 0.32 to 0.6, 0.15 to 0.65 and 1.1 to 1.2 mg/l, chromium ranged from 1.04 to 1.1, 1.06 to 1.11 and 1.1 to 1.11 mg/l, cadmium ranged from 0.2 to 0.4, 0.13 to 0.38 and 0.3 to 0.8 mg/l, respectively. Results of some parameters like nickel, lead, chromium and cadmium were found above the permissible limits of Pak-EPA. So it is recommended that Waste water should be treated at industrial territory. Only treated water should be allowed to drain into Lai stream.

Keywords: Wastewater, physicochemical parameters, heavy metals, treatment plant, Pak-EPA.

Introduction

Water is fundamental need of life for every living thing on earth which is abundantly available to Pakistan both from ground and surface water sources. Water quality is affected due to high demand for different usage which further increases water pollution in Pakistan. World Bank statistics shows that major cause of different infections in Pakistan is associated with water pollution. Global ranking of poor water management and monitoring shows that Pakistan stands on 80th position which proved that water scarcity is critical problem face by people of Pakistan. Major cause of decline in water quality is anthropogenic activities which contribute significantly towards environmental and public health damages in Pakistan. Major anthropogenic activities are lack of disposal system on municipal level, use of high level agrochemical products in agriculture sector and ejection of industrial water in surface water reservoirs affect water quality situation in Pakistan (Azizullah et al., 2011). Wastewater is defined as any water which is adversely impacted by anthropogenic activities. Anthropogenic activities result in increased concentration of heavy metals and contaminations. This eventually affects aquatic life and its proper development (Abdel-Satar et al., 2017). Root cause of water pollution includes municipal, industrial and agricultural discharge which is enhanced by the poor management of water sources and lack of effective implication of environmental quality standards. Water quality can be improved by economic alteration, technological improvement, and institutional and policy modifications (Hu and Cheng, 2013). Water quality has main concern in today's era as good water quality also ensures food safety. Inadequate quality of water and food due to water and soil pollution poses serious threats like carcinogenic effects on human health (Lu et al., 2015). Heavy metal contamination threatens the environment due to its toxic nature. Humans are exposed to heavy metals which may cause various disorders and diseases. Humans are exposed to heavy metals through ingestion (eating and drinking) or inhalation or through contact. Pollution caused by pharmaceutical waste, personal care products waste or other domestic pollutants result in developmental, reproductive and behavior changes in fish and affects aquatic life when enter into surface water (Holeton et al., 2011). People working and living near sites where heavy metal improperly disposed are more exposed to heavy metals (Martin and Griswold, 2009). On ingestion these heavy metals combine with biological molecules of body i.e. proteins and enzymes and thus disrupt their structure and proper functioning in human body (Duruibe et al., 2007). Lead, cadmium, arsenic and mercury are considered as threats to human health in case of their higher accumulation. Lead due to its higher gastrointestinal uptake and blood brain permeable barrier cause neurotoxic effects and reduces blood level (Jarup, 2003). Children are considered as one of most vulnerable groups of urban population affected by heavy metal pollution. This major source of heavy metal into children comes from soil to which they are in contact. Thus there is a need to deal with heavy metals by overcoming soil pollution (Tepanosyan et al., 2017). Increased concentration of Pb and Cd greater than safe limits in children and adults poses potential carcinogenic risks (Belkhiri et al., 2017). Other than this long term exposure to arsenic may cause skin cancer and nervous system disorder. Inhalation of arsenic may cause lung cancer (Jarup, 2003). Study has been conducted on impact of discharge wastewater effluent on the physic-chemical qualities of a receiving watershed in a typical rural community. Study concluded that adverse impacts of discharge of waste water effluent poses threats to the health of rural communities which depends on such receiving water bodies for their domestic water use (Igbinosa and Okoh, 2009). Use of waste water for irrigation also has impacts on effective functioning of soil. Soil salinization and chloride content increase with persistent exposure of waste water in the field. Increase in soil salinization cause increase in electrical conductivity (Christou et al., 2014). Industrial waste water when enter into soil it may cause increase in pH and reduce electrical conductivity of soil. This cause to effect biota of soil, arthropods living in soil may survive pH increase but cannot bear low electrical conductivity (Stenchly et al., 2017). Human induced activities are considered as major reason behind environmental disturbances. Aquatic life is also affected by such anthropogenic activates and disturb normal functioning of aquatic ecosystem (Knight et al., 2014). Pollution caused by pharmaceutical waste, personal care products waste or other domestic pollutants result in developmental, reproductive and behavior changes in fish and effects aquatic life when enter into surface water (Holeton et al., 2011). Severe pollution caused by waste water discharge adversely affects aquatic life and reduces the development of aquatic environment. Effective working of waste water treatment plant can reduce pollution load in river and stream. 80% reduction in pollution through wastewater treatment plant can improve water quality of river up to 80% (Lee et al., 2017). Purpose of study was to find effectiveness of treatment used for sewage water prior to discharge into the stream. As there are physical, chemical and biological methods for removal of contamination from waste water. I-9 sewage treatment plant known for treatment of sewage water of 25 sectors a day and has capacity of 17 million gallons per day of water treatment. It helps to find out efficiency of treatment plant by assessing results before and after the treatment.

Materials and Methods

Samples for study collected from the study area which is I-9 treatment plant, Islamabad. Three different sampling points were selected in the study area, i.e. influent, effluent and external stream. Composite samples were collected for one week and analyzed for various parameters. The pH, total dissolved solids (TDS) and electrical conductivity (EC) were determined through portable pH meter. While fluoride (F), chloride (Cl), sodium (Na) and potassium (K) were determined through lab analysis. For the assessment of heavy metals, water samples were digested with nitric acids (HNO_3). One hundred milliliters of water was taken and 10 ml of HNO_3 was added and placed on a hot plate in the fuming hood at 120 °C for few minutes. When the volume was reduced, distilled water was added to dilute the sample. The sample was filtered and the volume was raised to 100 ml by adding distilled water, and finally the prepared samples were subjected to atomic absorption spectrophotometer for determination of heavy metal concentration. Some of the parameters like Copper (Cu), Zinc (Zn), Iron (Fe), Manganese (Mn), Nickel (Ni), Cadmium (Cd), Lead (Pb), and Chromium (Cr) were analyzed by using Atomic Absorption Spectrophotometer.

Results and Discussion

Different parameters are analyzed to check the efficiency of waste water treatment plant by comparing difference between the results of influent and effluent as well as by the standards of Pak EPA. The pH and EC of influent sample ranged from 6.2 to 6.9 and 840 to 1250 µS/cm, respectively. While there is slight change in the values of pH after treatment in effluent stream i.e. 6.4. to 6.9. Contrary to this electrical conductivity of effluent reduced to greater extent ranged from 830 to 930 µS/cm. Samples for the study were also collected from nearby passing external stream. The pH of this sample is average 6.85 while electrical conductivity was 795 µS/cm. Increase in pH and electrical conductivity may be because of increase in soil salinity which causes reduction in plant growth (Christou et al., 2014). TDS in influent ranges from 570 to 850 mg/l while TSS is found in concentration between 0.062 to 0.094 mg/l. These results showed slight variation after treatment in such a way that TDS ranged from minimum of 570 to 630 mg/L maximum and TSS from 0.008 to 0.42 mg/L. While external stream had TDS and TSS concentration averages of 540 and 0.069 mg/l, respectively. Results of TDS compared with national environmental quality standards of environmental protection agency (EPA). It was found that TDS of both influent and effluent samples was within permissible limit (Table 1). Results indicate concentration of fluoride and chloride in influent and effluent as follows. Fluoride and chloride found in influent with concentration ranging from 0.4 to 4.7 mg/l and 48 to 180 mg/l, respectively. Contrary to this in effluent sample their concentration reduces in such a way that fluoride found minimum of 0.8 mg/L to maximum of 3.5 mg/L while chloride was minimum of 56 mg/L to maximum of 71 mg/l. The concentrations of fluoride and chloride found in external stream are 2.1 and 49.5 mg/l, respectively. These parameters were compared with EPA standards and it was found that permissible limit for fluoride and chloride is 10 and 1000 mg/L in effluent water. Samples found contaminated with various metals among which iron (Fe), manganese (Mn), zinc (Zn) and nickel (Ni) had varied concentrations in influent and effluent water samples. Concentrations of Fe and Mn in influent water ranged from 0.16 to 2.938 mg/l and 0.193 to 0.579 mg/l, respectively.

Similarly, Zn and Ni had concentrations in influents water ranging from 1.9 to 2.7 mg/L and 1.19 to 1.66 mg/L. Contrary to these values there was slight change in concentration after treatment. While in effluent Fe and Mn contents ranged from 0.745 to 2.055 mg/L and 0.1 to 0.861 mg/L respectively. Likewise Zn and Ni contents ranging from 1.8 to 2.5 mg/L and 1.15 to 1.56 mg/L, respectively. While in external stream Fe, Mn, Zn and Ni concentrations were 3.02, 0.62, 2.54 and 1.16 mg/L respectively, (Table 2). These values were compared with EPA guidance and found that Fe concentration slightly varied from standard i.e. 2.0 mg/L. While Mn, Zn and Ni were found within limits i.e. 1.5, 5 and 1.0 mg/L, respectively. Study revealed that children are highly susceptible to iron toxicity as they are exposed to a maximum of iron-containing products. Iron toxicosis occurs in four stages. The first stage which occurs after 6 hrs of iron overdose is marked by gastrointestinal effects such as gastro intestinal bleeding, vomiting and diarrhea. Iron can initiate cancer mainly by the process of oxidation of DNA molecules.

Samples were also contaminated with accumulation of Pb, Cr and Cd. Influent had concentrations of Pb, Cr, and Cd in the range from 0.32 to 0.6 mg/L, 1.04 to 1.1 mg/L and 0.2 to 0.4 mg/L, respectively (Table 3). There was very less variation in the concentration of contaminants in samples after treatment i.e. 0.15 to 0.65 mg/L for Pb, 1.06 to 1.11 for Cr and 0.13 to 0.38 mg/L for Cd in effluent water. Contrary to these, external stream had concentrations of 1.18, 1.11 and 0.53 for Pb, Cr and Cd, respectively. These values in both cases i.e prior to treatment and after treatment had higher concentrations than permissible limits provided by EPA which are 0.5 mg/L for Pb, 1.0 mg/L for Cr and 0.1 mg/L for Cd. While external stream had values of Pb, Cr and Cd higher than permissible limit. Study revealed that higher concentrations of Pb and Cd than safe limits pose threats to human health. This causes health hazard and potential non-carcinogenic health risk to the humans (Belkhiri et al., 2017). Accumulation of Pb and Cd in water body may affect its population and reduces the functioning of aquatic environment (Singh and Kumar, 2017). Cr contamination affects functioning of plants as it causes seizing of plant germination, nutrition, photosynthesis resulting oxidative stress (Gomes et al., 2017).

Table 1 Analysis of Physio-chemical metals concentrations in selected Influents samples of I-9 treatment plant.

Samples	pH	EC (µS/cm)	Concentration (mg/l)										
			TDS	TSS	F	Cl	Fe	Mn	Zn	Ni	Pb	Cr	Cd
Day-1-influent	6.2	980	660	0.094	2.2	54	1.17	0.285	2.3	1.7	0.4	1.1	0.2
Day-2-influent	6.6	930	630	0.076	4.7	53	2.25	0.526	2	1.6	0.6	1.1	0.3
Day-3-influent	6.7	840	570	0.088	0.7	48	2.938	0.435	2.6	1.2	0.3	1.1	0.2
Day-4-influent	6.6	1250	850	0.062	0.4	180	0.16	0.579	2.7	1.4	0.3	1.1	0.3
Day-5-influent	6.6	970	660	0.09	2.2	53	2.092	0.25	2.1	1.2	0.5	1	0.4
Day-6-influent	6.9	970	660	0.093	1.1	60	2.137	0.193	1.9	1.2	0.3	1.1	0.4
Minimum	6.2	840	570	0.062	0.4	48	0.16	0.193	1.9	1.19	0.32	1.04	0.2
Maximum	6.9	1250	850	0.094	4.7	180	2.938	0.579	2.7	1.66	0.6	1.1	0.4
Pak EPA	6-9		3500			1000	2	1.5	5	1	0.5	1	0.1

Table 2 Analysis of Physico-chemical metals concentrations in selected effluents samples of I-9 treatment plant.

Samples	pH	EC (µS/cm)	Concentration (mg/l)										
			TDS	TSS	F	Cl	Fe	Mn	Zn	Ni	Pb	Cr	Cd
Day-1-effluent	6.4	830	570	0.076	3.5	70	1.05	0.35	2	1.5	0.4	1.1	0.2
Day-2-effluent	6.7	850	580	0.42	1.3	66	2.055	0.51	3	1.6	0.7	1.1	0.1
Day-3-effluent	6.5	840	570	0.008	0.8	56	1.187	0.403	2	1.2	0.3	1.1	0.2
Day-4-effluent	6.6	930	630	0.057	1.1	71	0.745	0.1	2	1.3	0.3	1.1	0.2
Day-5-effluent	6.9	920	630	0.067	2.3	60	1.682	0.861	2	1.3	0.2	1.1	0.4
Day-6-effluent	6.9	910	620	0.041	0.9	60	1.801	0.524	2	1.3	0.3	1.1	0.4
Minimum	6.4	830	570	0.008	0.8	56	0.745	0.1	1.8	1.15	0.15	1.06	0.13
Maximum	6.9	930	630	0.42	3.5	71	2.055	0.861	2.5	1.56	0.65	1.11	0.38
Pak EPA	6-9		3500			1000	2	1.5	5	1	0.5	1	0.1

Table 3 Analysis of Physicochemical metals concentrations in selected external stream samples of I-9 treatment plant.

Samples	pH	EC (µS/cm)	Concentration (mg/L)										
			TDS	TSS	F	Cl	Fe	Mn	Zn	Ni	Pb	Cr	Cd
Day.1. 1External Stream	6.9	700	480	0.069	2.9	44	2.673	0.85	2.3	1.2	1.2	1.1	0.8
Day.2. External Stream	6.8	890	600	0.068	1.2	55	3.374	0.407	2.8	1.1	1.1	1.1	0.3
Average	6.85	795	540	0.069	2.1	49.5	3.0235	0.629	2.54	1.16	1.18	1.11	0.53
Pak EPA	6-9					1000	2	1.5	5	1	0.5	1	0.1

Chromium also affects human health by disrupting kidney function. It causes nephrotoxicity and reduces renal function. Co-exposure of Cd and Pb with Cr reduces glomerular filtration rate (Tsai et al., 2017). Results clearly indicate that no significant treatment was provided for the removal of heavy metals. While external stream was also contaminated and contain higher contents of heavy metals.

Conclusion

Waste water is collected through pipe line and after treatment released into Lai stream which contains different kinds of waste water including municipal sewage and industrial waste water. All the treated water gets mixed with polluted water which becomes unsafe for utilization as irrigation water. When the water containing heavy metals leaches down to the ground water, it will contaminate the water which is normally used for washing and drinking purpose. The results show that waste water containing heavy metals, is the evidence that industrial water getting mixed with domestic waste water can cause serious risk to environment. Heavy metals such as lead, chromium etc lead to diseases like cancer when they get mixed with drinking water.

Part of treatment plant is under maintenance only 1/3rd is working for last few months treating only the waste water of I-9. Population around two millions is living on the bank of Lai stream. Lai is basically a stream to deal with rain water during rainy season. It should be protected from further contamination due to treatment plant. To ensure this, treatment plant must be made more than 90% efficient. Waste water should be treated within industrial boundary and only treated water should be discharged into Lai stream.

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