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Assessment of the Efficiency of Wastewater Effluent Treatment Plant at Steel Mill, Karachi

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ABSTRACT

The purpose of this study is to evaluate how well Steel Mill Karachi's wastewater treatment system works. Wastewater treatment facilities employ the activated sludge technique. Several influent and effluent locations allowed for the collection of influent and effluent samples. Physicochemical parameters were measured to evaluate effluent treatment plant efficiency. In a lab environment, the sample's analysis findings were compared to Sindh Environmental Quality Standards (SEQS) for Pakistan. EC, BOD5, COD, SO_4^{-2}, Ca, Mg, Na, K, TDS, TSS, EC, BOD_5, COD, SO_4^{-2}, Ca, Mg, Na, K, Fe, and Zn were removed to different degrees: 42.93%, 60.33%, 43.63%, 51.53%, 40.5%, 35.56%, 26.33%, 22.12%, 34.09%, 20.75%, 55.87%, 22.12%, and 76.10%. Only two metrics, the COD and Zn concentrations, were over the SEQS limits, keeping other effluent results parameters within the limits. Additionally, it is advised that proper maintenance be carried out to increase the effectiveness of wastewater treatment plants.

Keywords: Influent, Effluent, Wastewater, Treatment Plant, Steel

1. INTRODUCTION

Water is commonly found on the planet earth and is the one of the most important chemical compounds present in the environment. Every living thing on Earth depends on water for its survival as well as growth. The percentage of water on Earth is only 70%. However, the environment is highly polluted because of human activities, industrialization, agricultural use of fertilizers, and the growing human population. The quality of the drinking water must be regularly assessed because the human population acquires several water-borne ailments as a result of using contaminated water. As water chemistry tells a lot about the metabolism of the ecosystem and the main hydro-biological processes, it is difficult to fully understand biological phenomena (Basavaraja Simpi et al. 2011).

Sewage treatment in Pakistan has not yet advanced to a sufficient degree. Industries must set up their wastewater treatment systems and refine their operational parameters in order to prepare for the future. Due to its higher biological oxygen demand (BOD) values, untreated industrial effluent may cause streams to lose dissolved oxygen (DO) when released directly into them. The discharges have higher BOD and chemical oxygen demand (COD) levels, both of which pose serious risks to aquatic life (Palamthodi et al. 2011). Water quality before it is acquired relies on its source and transportation routes (Ahmed et al. 1993). The global soil ecology has been harmed by anthropogenic activity, which has detrimental effects on the entire food chain (Tu et al. 2000, Dahmani-Mueller et al. 2001, McGrath et al. 2002). Surface water resources in developing nations are at risk from untreated wastewater discharge from household farming and industrial activities (Kambole 2003). The principal cause of the rise in the concentrations of fecal coli form, BOD, COD, total dissolved solids (TDS), total suspended solids (TSS), and TSS in streams is the discharge of organic content from wastewaters (Kulkarni 2007). The preference for using water for many households, agricultural, and other uses has declined as a result of this water condition (Hari Om et al 1994). A significant number of chemicals are released into streams as a result of industrial processes, endangering the ecosystem (Parvathi et al. 2009). Industrial waste must be treated on-site before being deposited into the sewer system because it is the main source of contamination in all ecosystems (Emongor et al. 2005). Many solid, semi-solid, and liquid wastes are produced during the development of these businesses, and if they are disposed of in the environment without being treated, they may include considerable amounts of hazardous organic and inorganic contaminants. Furthermore, this will unquestionably lower soil productivity and negatively affect crop production in the sorroundings. Industrial effluents considerably changed the quantities and distribution of ions in wheat and bean plants (Shukry 2001, APHA 1995). Additionally, the production of steel results in a significant concentration of contaminants, primarily heavy metals (Metcalf 2002). Heavy metal contamination in wastewater from steel mills is possible and is brought on by the addition of dissolved and suspended pollutants (Sponza and Karaoğlu 2002). Backwater water drainage into natural settings has a adverse effect on both land and marine ecologies. The metal contamination has a detrimental effect on the food chain and food web as well. The metallic pollution in industrial drainage has somehow decreased since environmental regulations were put in place (Quevauviller et al. 1989, Zinabu et al. 2018, Förstner and Wittmann 2012). In Pakistan, wastewater treatment facilities have been developed to handle the waste from a variety of businesses, including the steel, leather, pharma, and textile industries. The environmental pollution in the vicinity of companies has been brought on by industry wastewater rather than these plants.

This research study aims to assess the efficiency of WWETP (Waste Water Effluent Treatment Plant) at steel mill Karachi. Total dissolved solids (TDS), electrical conductivity (EC). total suspended solids (TSS), pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), magnesium (Mg), sulphate (SO_4^{-2}), calcium (Ca), zinc (Zn), iron (Fe), sodium (Na), potassium (K), concentrations in both influent and effluent samples were all thoroughly analyzed in the study in order to determine the efficacy of the wastewater treatment plant. Additionally, to gauge compliance, the resulting analysis findings were contrasted with standard environmental quality standards (SEQs). The study's objective was to produce useful suggestions and remedial actions that would improve the efficacy of wastewater treatment based on its findings.

2. MATERIALS AND METHODS

2.1 Area of study

The Pakistan Steel Mill, a wastewater treatment plant for the Karachi steel mill, was the site of this study. Zulfiqar Ali Bhutto, who was Pakistan's prime minister at the time, lay the foundation stone for Pakistan Steel Mills Corporation (PVT) LTD on December 30, 1973. 40 kilometres southeast of Karachi, adjacent to Port Muhammed Bin Qasim, is where you'll find Pakistan Steel Mill. As depicted in Figure 1, the mill is situated across a section of the national highway that runs down the coast and is linked to the railway network.

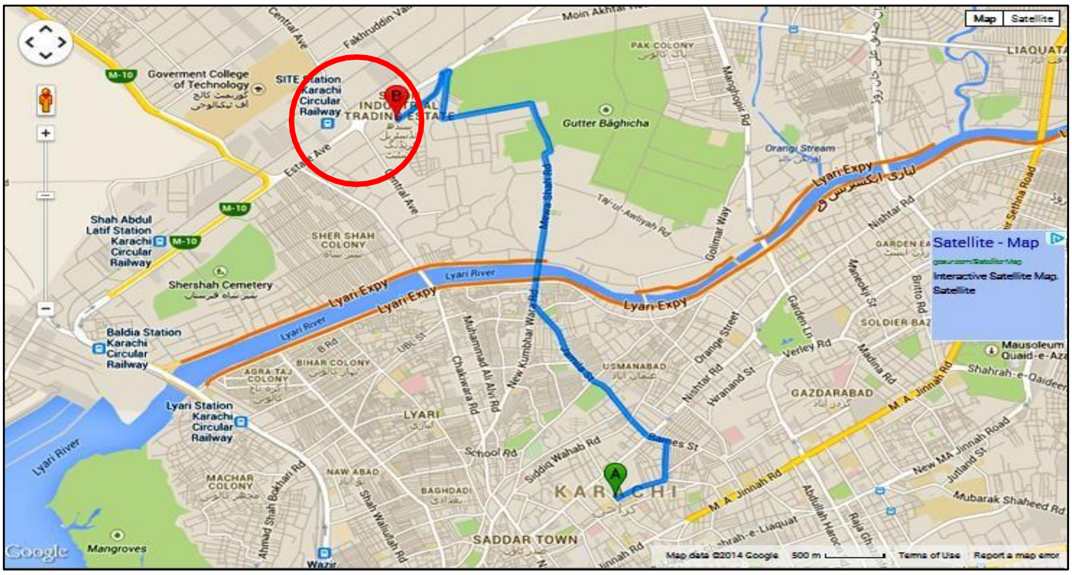

Figure 1. GIS Map of Pakistan Steel Mill Karachi

Pakistan Steel Mill spans 18,600 acres (29 square miles). From a total of 10,390 acres, 8070 acres were maintained for the town and 200 acres for the water basin. The facility has a 45950 m^2 footprint and can process 12000 m^3/day of influent. The roadway and railroads connect it to the mill site, laying the foundation for the coastal network. Pakistan Steel Mill has a total area of 18,600 acres (29 square miles), of which 200 acres are used for water reservoir expansions and 10390 acres are used for the central pant.

2.2 Methodology

The approach used to accomplish this goal was quite straightforward. The samples were collected from three main locations: two were influent, which came from the steel mill's main plant and nearby commercial districts, and the third was effluent, where cleaned water was being discharged into an agriculture form.

Weekly samples were taken from the wastewater treatment facility at the steel mill, and testing was done in the labs of the environmental engineering department at MUET Jamshoro. Three samples were taken early each week from the identified places above. In the area study map displayed in figure 1.2, the areas are highlighted. In total, 18 samples were collected over the course of 6 weeks. Samples were taken roughly 10 meters apart from the influent and effluent on each side. Samples were taken in 1-liter bottles, which underwent a thorough cleaning with distilled water before to being refilled with wastewater. This formula was used to determine the combined concentration of Influent samples 1 and 2 (Qian, 1999).

$$\mathbf{L_0 = (QwLw + QrLr) / Qw + Qr} \qquad \mathbf{(1)}$$

Here, **Qw** stands for the volumetric flow rate of the stream carrying influent 1 and wastewater from the primary treatment facility, the final outcome of influent 1 is **Lw**. **Qr** is the volumetric flow rate of the stream where influent 2 is drawn from and wastewater from the commercial and industrial area is discharged. The final outcome of influent 2 is **Lw**. The final combination of influents 1 and 2 is $\mathbf{L_0}$.

The physicochemical peremeters such as TDS, TSS, EC, pH, BOD, COD, sulphate,Ca, Mg, K, Na, Fe, Zn were determined by using standerd methods (Csuros and Csuros 2016).

Table 1: Shown the parameters, units, instruments and methods.

Sr. No	Parameters	Units	Instruments and Methods
1	TDS	mg/L	TDS meter
2	TSS	mg/L	Spectrophotometer
3	EC	mS/cm	Conductivity meter/TDS meter
4	pH	-	pH meter
5	BOD	mg/L	Titration method
6	COD	mg/L	COD meter
7	Sulphate	mg/L	Spectrophotometer
8	Ca	mg/L	Atomic Absorption Method
9	Mg	mg/L	Atomic Absorption Method
10	K	mg/L	Atomic Absorption Method
11	Na	mg/L	Atomic Absorption Method
12	Fe	mg/L	Atomic absorption method
13	Zn	mg/L	Atomic absorption method

2.3 Features of Wastewater Treatment Plant

Two various kinds of influent streams are fed into the wastewater treatment facility. The first type comes from the steel mill's principal plant, while the second type is a composite source that includes effluents from various places close to Steel Mill Karachi. Regarding composition and features, these distinct influent streams provide special difficulties.

Specific pollutants connected to the processes used to make steel are anticipated to be present in the influent from the primary plant, however the combined influent may differ in terms of the load and composition of pollutants due to the varied sources. The efficacy of the wastewater treatment facility must be evaluated in light of these fluctuations, and the treatment procedures must be adjusted as necessary. The treatment facility can improve its performance and guarantee the efficient removal of pollutants from both streams, contributing to overall environmental sustainability and legal compliance by recognizing and addressing the unique characteristics of each influent type. To eliminate contaminants from wastewater, the wastewater is processed through various sections where various procedures take place (Figure 2).

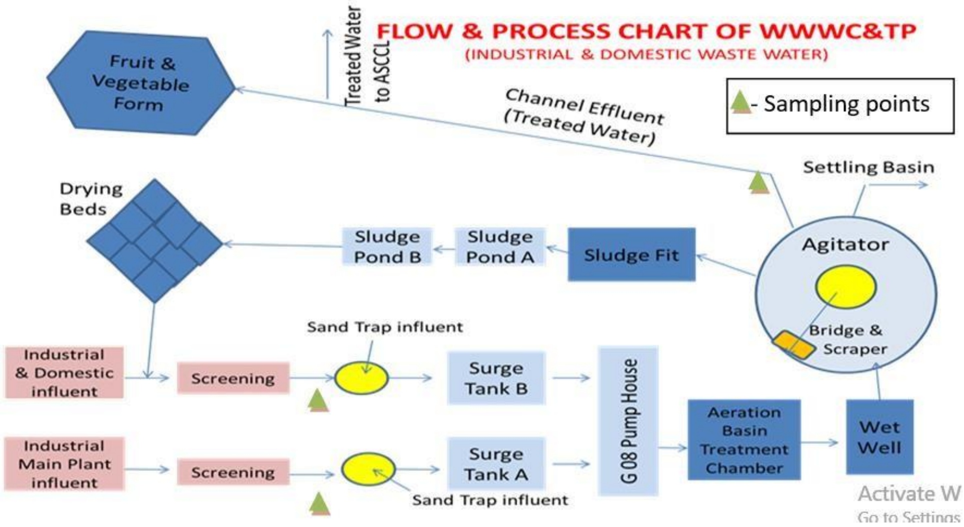

Figure 2: Process Flow Diagrams of Wastewater Treatment Plant of steel Mill

Table 2: Removal efficiency physicochemical parameters during the period of data collection

Sr. No	Parameters	Influent	Effluent	Removal %	NEQS
1	TDS mg/L	1200.47	685	42.93	3500
2	TSS mg/L	256.07	101.83	60.33	150
3	EC mS/cm	2.05	1.34	34.63	-
4	pH	7.96	7.28	-	6-10
5	BOD mg/L	122.62	59.43	51.53	80
6	COD mg/L	492.2	292.83	40.5	150
7	Sulphate mg/L	450.27	290.13	35.56	600
8	Ca mg/L	107.69	79.33	26.33	-
9	Mg mg/L	106.57	83	22.12	100
10	K mg/L	69.19	54.83	20.75	-
11	Na mg/L	173.14	114.12	34.09	200
12	Fe mg/L	4.26	1.88	55.87	2
13	Zn mg/L	30.55	7.3	76.1	5

3. RESULTS & DISCUSSION

Various samples were taken, and the following indicators were analyzed, to assess the efficacy of wastewater management in the continuous casting division and to recognize the influence that industrial wastewater can have on the degree of contamination of surface waters where it is released, and consequently on the natural ecosystem. Input and effluent TDS results ranged between 1200.47mg/L and 685mg/L, respectively. TDS removal efficiency was 42.93%, and effluent was within NEQS standards. TSS concentration readings for influent and effluent were 256.07mg/L and 101.83 mg/L, respectively. TSS was below the NEQS limit, and the concentration removal rate was observed as 60.33%. The EC concentration in the influent was 2.05 mS/cm and 1.34 mS/cm in the effluent. The removal efficiency was 34.63%. In the influent and effluent, the acquired pH results fell within the ranges of 7.96 and 7.28, respectively. BOD of influent was 122.62 mg/L and 59.43 mg/L in the effluent, respectively. The outcome was within the NEQS range, with a removal percentage of 51.53%. The COD concentration in the influent and effluent was 492.2 mg/L and 292.83 mg/L, respectively.

The effluent was over the NEQS standard, and the removal percentage was 40.5%. The concentration of sulphate of the influent 450.27 mg/L and 290.13 mg/L for the effluent. The removal efficiency for sulphate concentration was 35.56%, and the outcome was displayed in the NEQS limit. The calculated calcium levels for the influent and effluent were 107.69 mg/L and 79.33 mg/L respectively. The removal percentage was observed to be 26.33% and the effluent was within NEQS limits. Magnesium concentrations were calculated to be 106.57 mg/L in the influent and 83 mg/L in the effluent. The outcome was below the NEQS standard, and the percentage of removal was 22.12%. Potassium concentrations in influent and effluent were 69.19 mg/L and 54.83 mg/L, respectively. The eliminated concentration as a percentage was 20.75%. It was determined that the influent and effluent had sodium concentrations of 173.14 mg/L and 114.12 mg/L, respectively. The outcome was below the NEQS level, and 34.09% was covered up. 4.26 mg/L of iron was found in the influent and 1.88 mg/L in the effluent, respectively. 55.87% of the concentration had been removed, and the effluent was under NEQS limits. Zinc concentrations in influent and effluent were 30.55 mg/L and 7.3 mg/L, respectively. The percentage of zinc that was eliminated was 76.1%, which was more than the NEQS standard. Further table 2 shows results and figure 3 shows graphically removal percentage of concentration below.

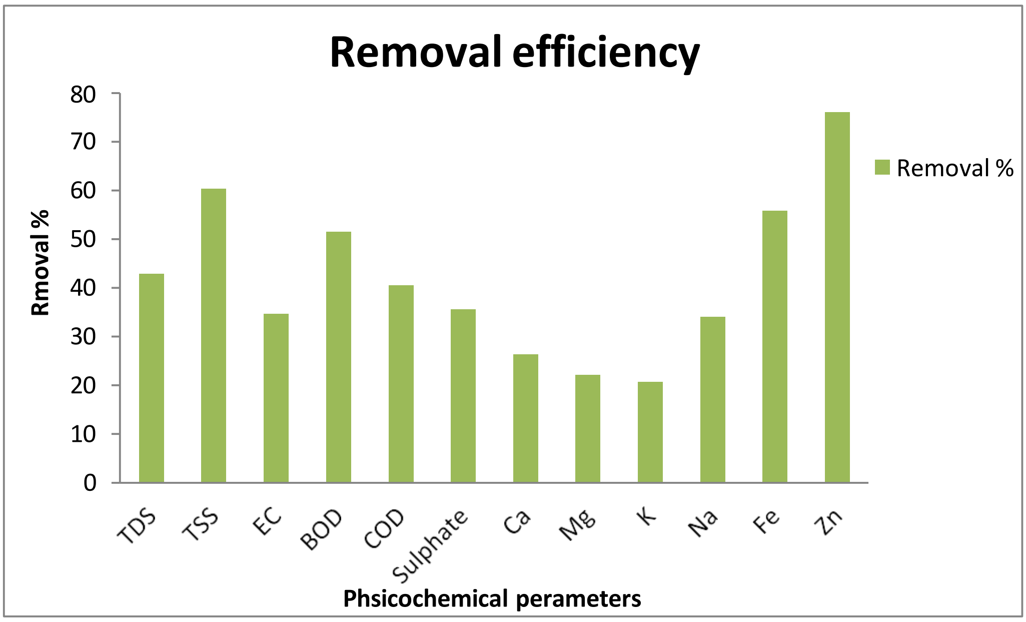

Figure 3: The removal efficiency of physicochemical parameters.

4. CONCLUSION

The performance of the treatment plant was evaluated by analyzing a number of physicochemical factors in the samples that were collected. These parameters included Total Dissolved Solids (TDS), Electric Conductivity (EC), Total Suspended Solids (TSS), pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), and a number of metals, including sulphate, magnesium (Mg), sodium (Na), calcium (Ca), iron (Fe), potassium (K), and zinc (Zn). It is concluded that the two parameters i.e. Zn and COD are higher than the prescribed limit of NEQS and needed to be treated by some latest cost effective techniques.

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