INVESTIGATION OF EFFLUENT WATER OF STEEL INDUSTRIES, ISLAMABAD, PAKISTAN

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ABSTRACT

Water quality and shortages are some of the major issues being faced. The objective of research is to examine and evaluate the quality of water effluents and discharge rate to calculate pollution load from all of the steel industrial sectors, Islamabad in 2020. The surprising increase in the water table depth is due to the excess use of water by industrial sector that was also estimated from thirteen industrial units that were first scrutinized from the total number of industries on basis of effluent flow while a one-point source of Nala layi was selected and all the samples were analyzed for several physical and chemical parameters like pH, TDS, TSS, COD, BOD and O&G and heavy metal contents. The pH values of steel units were range from 3.2-9.9, TDS 881-3633 mg/l, TSS 107-1143, COD 96-829, BOD 28-354, and O&G concentration range was between 1.9-14.5. The concentration of heavy metals from steel units and Nala layi was observed in ranges Pb 0.156-0.5 mg/l other than industries that were BDL while Nala layi was 2.17mg/l, Fe 1.28-13.08 mg/l while Nala layi was 2.17mg/l, Ni 0.02-3.79 and concentration in Nala layi was 3.2mg/l. Cr values including Nala layi point were usually below from detection limit while those which were recorded were ranging between 0.33-5.01mg/l, Cu 0.18-5.77 mg/l while Nala layi concentration was 0.31 mg/l, As was throughout very low to detect while only two points showed concentration around 0.01mg/l which was neglectable. Zn 2.1-36.1 while Nala layi concentration was 3.52mg/l. Flow was calculated for assessing pollution load w.r.t COD 228441089.8 mg/month while pollution ratio was observed as 2.5:1. Mentioned heavy metals were calculated in terms of per year effluents as Pb = 20.20392674, Fe = 920.3596885, Ni = 189.2906642, Cr = 120.4780281, Cu = 234.9172441, As = 0.208749059 and Zn = 891.8803527 kg’s per year. On the bases of high results COD, TSS results it was suggested to install ASP (activated slug process) and use potash alum for flocculation and coagulation process.

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DEDICATION

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ABBREVATIONS

Pak-EPA	Pakistan Environmental Protection Agency
PEPA	Pakistan Environmental Protection Act
AAS	Atomic Absorption Spectrophotometer
NEQS	National Environmental Quality Standards
WHO	World Health Organization
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solids
JICA	Japan International Cooperation Agency
MSI	Mustehkam Steel Industry
KSR	Karachi Steel Industry
MAT-CAST	Fazal Steel
SSI	Sadiqui Steel Industry
R-R	Re-Rolling
GPS	Geographic Positioning System
GIS	Geographic Information System
TDS	Total Dissolve Solids
HM	Heavy Metals
mg/L	Milli gram per liter
NCS	National Conservation Strategy
μ	Average
SEC	Specific Energy Consumption

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CHAPTER 1

INTRODUCTION

1.1 Water Pollution and Pakistan Status

Water is a paramount natural resource manifesting the life on the planet Earth. Two third of the planet's surface is occupied by water bodies. Nevertheless, reservoirs of fresh water are limited and fittest of resources for human beings. According to an estimate, the Asian population of over one billion and 150 million Latin Americans relies on underground aquifers. 50% of the groundwater is derived from wells, boreholes, and springs in the developed countries (Clarke *et al*., 1995).

Water is crucial to sustaining life, and there is no substitute for water that can support lifeforms. It is a significant requisite for subsistence and growth of human society (Toqeer *et al.,* 2004). Water is deemed safe for consumption if it exhibits no significant malady within a generation lifetime. Unfortunately, one billion world population lack access to safe and clean water resource (Farhat *et al.,* 2014).

3% of the total earth's water reserve is consumable freshwater, where 0.001 % of it is accessible by the human communities worldwide. Nevertheless, it is unfortunate that population growth and unsustainable use of resources have burdened the resource beyond its carrying capacity therefore compromising tits quality (Hinrichsen and Tacio, 2002). Quality of Water demands attention as it is fundamental for human welfare (Zainab *et al*., 2015). Its quality keeps varying both spatially and temporally. Water is a dynamic system hosting a myriad of biotic and abiotic components. It includes many soluble and suspended, organic, and inorganic substances (Sharma *et al*., 2011). In the current world scenario, the availability of consumable surface and groundwater is a matter of sheer concern. The cleanliness of drinking water determines public health safety (Tahir *et al.,* 2008; Amber *et al.,* 2009). According to the UN report, 1.1 billion individuals lack access to clean drinking water, 2.5 billion people suffer due to poor sanitation systems and approximately 5 million annual casualties are due to water-borne diseases (Azizullah *et al.,* 2011).

The state of Pakistan was blessed with the water resource suffice to support the whole nation. Nevertheless, the inefficient consumption of water for variable purposes has deteriorated the quality of water, leading to a shortage of usable water (Ammarah and Nawaz, 2014). The water crisis making an appearance due to the pollution is directly or indirectly leading to several health problems among citizens. It is feared that soon, the water scarcity will worsen the situation victimizing thousands of individuals. Pakistan is already being counted in the world water-scarce countries (WB., 2005).

The majority of the population of Pakistan depend on groundwater for drinking purpose, with a small proportion relying on surface water reservoirs. According to Pak-SCEA Report 2006, 80% of Punjab's groundwater is freshwater whereas salty water is present in the northern Punjab and desert areas. Conversely, only 30% of the water in Sindh is fresh and consumable. The major proportion of groundwater in Sindh and Baluchistan is brackish. Moreover, in Khyber Pakhtunkhwa increasing abstraction has rendered its waters saline (Pak – SCEA, 2006).

Water is regarded as a finite resource, as only 2.5% of the total volume is freshwater where half of it is locked in confined aquifers and glaciers. According to an estimate, 53 nations constituting half of the world population will probably face fresh-water scarcity by 2025 (Pani Pakistan, 2017). In Pakistan, PCRWR has reported that urban water supply is insufficient to meet public demands. Only 25.61% population in the country has access to clean water (Mahmood and Maqbool, 2006).

Water sustains the life and survival of mankind. Freshwater reserves are valuable assets and their extinction can be deadly for humans. A country is considered water-stressed, when water supply falls below the demand level, given the required per capita demand for water is 1700 cubic meters per annum. The consumption requirement greater than 1700 cubic meters per person per annum pressurizes the water resource carrying capacity. According to a report, in 2006 the population of 700 million individuals equivalent to 43 countries has the water supply much below the requisite demand of 1700 cubic meters (Tahir *et al*., 2010). It is also reported by the United Nations that 1 out of every 6 individuals has no access to clean water for drinking.

The population of Rawalpindi city exceeds 2.1 million and relies primarily on the groundwater. The drinking water is accessed through tube wells and boreholes. Nullah Lai is a natural rainwater fed stream passing through the center of the city. However, water quality is highly deteriorated by the dumping of domestic waste and sewage water pollution. The effect is depicted in the estimation that approximately 30% of maladies and 40% mortalities in Pakistan are due to the consumption of contaminated water (Haydar, 2009). Roughly 20 to 40% of hospital beds in Pakistan are occupied by victims of disorders associated with polluted water (Tahir and Bhatti, 1994). Moreover, 2.2 million people in developing countries die annually due to water-borne diseases (WHO, 2000).

Nullah Lai is the principal surface water reservoir in the city. The polluted water from Nullah infiltrates into the groundwater, thus modifying the physicochemical properties of groundwater. The contaminants, particularly heavy metals in drinking water can adversely affect the renal, hepatic, and cardiovascular systems of the human body (Khan *et al.,* 2011).

The polluted groundwater acquires attention at all three local, regional, and global level due to the fairly irreversible damage it can cause to ecosystems and public health (Ullah *et al.*, 2009).

Water pollution is among the significant threats to the health safety of citizens of Pakistan. Pakistan is in the 80th position in 122 nations concerning the quality of water. Drinking water obtained from either surface water reservoirs or groundwater is contaminated with pathogenic microflora, toxic metals, and pesticides causing public health problems thereof.

1.2 Literature Review

Among the issues faced by developing countries, the utmost crucial issue is the indecorous management of a substantial amount of wastes. These wastes are produced as a result of several anthropogenic activities. The hazardous discharge of these effluents into the environment is even more formidable. Water bodies specifically water reservoirs & streams go through the most severe consequences in this case. Due to this improper management, these natural resources have become inappropriate for primary as well as secondary utilization (Fakayode, S. O., 2005).

Industrial sewage contamination of natural water bodies has appeared as a major problem in most of the developing and densely populated countries. Mainly infected water bodies include Estuaries and inland water bodies. These water bodies are frequently polluted by the proceedings of the adjacent populations and industrial organizations (Sangodoyin, A.Y., 1995). The key means for the waste removal from the industries are the river systems next to them. This drainage of industries has caused a profound effect on water bodies. The physical, biological, and chemical nature of the water bodies can easily be amended by these effluents (Sangodoyin, A.Y., 1991). Pollution pressure on surface water from industrial, agricultural, and domestic sources has increased due to rising industrial activities (Ajayi S.O., 1981).

The wastes entering in these water bodies are in solid as well as in liquid forms. These wastes are primarily produced as a result of industrial, agricultural, and domestic actions. It results in major pollution of water bodies which are significant reservoirs of treated, untreated, or partially treated industrial effluents. Consequently, the environment and public health are affected to a greater extent (Osibanjo,O., Daso A P., 2011).

Industries are a substantial source of pollution for all sorts of environments. A diverse amount of contaminants/pollution can be released into the environment through public sewer lines depending on the type of industry. The effluents from industries mainly comprise of hygienic waste, process discharge from industrial wash waters, manufacturing, and uncontaminated water from heating and cooling activities (Glyn, H. J., 1996). An increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), toxic metals such as Cd, Cr, Ni, Pb, and fecal coliform has caused by the high level of pollutants in river water systems. Consequently, it makes water inappropriate for drinking, irrigation, and aquatic life. Industrial sewage varies from great biochemical oxygen demand (BOD) to biodegradable discharge produced mostly from human effluents, pulp and paper industries, slaughterhouses, tanneries, and chemical organizations (Emongor,.V. Nkegbe., 2005).

1.3 Steel Industries and their Environmental Prospective

Industries have an essential role in improving the economic system of rural areas. Steel industries usually provide employment opportunities to 300 – 1000 people per industry, according to their production size. Improvement in industrial activities has boosted production at massive scale. Progress in products and services of the steel industry is due to advanced technology and equipment. Significant revenue is generated by the production businesses. (Sibiya, 2011).

A large quantity of water is used in the steel industry. However, most of the water is reused or recycled. Water is mainly used for cooling, in addition to descaling and dust scrubbing. All sorts of water are consumed in steelmaking operations. Freshwater is mainly used in different processes, along with cooling in the furnace and rolling section.

There are two alternative routes for steel production. An integrated cycle, the virgin raw material is used to manufacture steel. The average water intake is 28.6 m^3/ton while the average water discharge is 25.3 m^3/ton in this route. In the electric route, steel is produced by melting scrap in an electric arc furnace (EAF). The average water intake in this step is 28.1 m^3/ton and discharge is 26.5 m^3/ton. This shows that there is less water consumption (3.3 - 1.6 m^3/ton) which is largely due to evaporation where the remaining 90% water is discharged and reused (approximately 88% in an integrated plant and 94% in an EAF-based plant).

The availability of freshwater and its quality is a matter of sheer concern, in the context of sustainability of the manufacturing and production operations. Though water and steel are reused and recycled in the cycle, recycling reduces water quality. So, steelworks are dedicated to either reduce water consumption or improve technologies for cleaning. Water should be cooled and desalinized otherwise salt content in circulation channels would affect both environment and the production plant (for instance, rolling mills). Major environmental issues include eutrophication pf the water resource due to phosphates, corrosion of metallic hardware caused by chlorine, where carbonates form scales in the pipes increasing the consumption demand of energy.

Desalination and crystallization of salts from the by-products of the process requires a substantial amount of energy as well as cause high CO_2 emission. According to statistics, factors that affect specific energy consumption (SEC) have been estimated to predict energy consumption in desalination. However, statistical analysis has shown a weak association between the SEC and the costs involved in water production. Also, salts recovered through desalination are usually of poor quality which cannot be reused. They are to be disposed of in landfills contaminating the leachate thereof.

For efficient water use in steel industries, a balanced and holistic approach is required. Along with actual water consumption, other aspects are also considered such as water quality and its availability, energy efficiency, and plant configuration. The approach must also be local with a suitable regulatory framework to cope with challenges related to water such as its availability, competition in the area, and seasonal shortage. Different ways of treating wastewater (clarification with flocculation or chemical sedimentation) to recycle and produce good quality water have reduced the burden on groundwater resources to a greater extent.

Literature showed that nanofiltration and reverse osmosis (RO) was applied for the treatment and recycling of wastewater coming from tannery and textile industries as effluents. Electro-dialysis and ion exchange facilities were installed for effluents discharged from the steel industry containing hydrochloric acid and nitric acid in it. Moreover, RO and ultracentrifugation amalgamation results in the production of deionized water from surface water. With this, RO can be proved more efficient in combination with back-washable microfiltration, pre-treatment technique. This pretreatment helps to avid fouling which may happen in the RO process. In addition to this, colloidal suspended Organic matters can also be screened out with this combination.

1.4 Water Bodies as Effluents Sink

Several water resources have made hazardous to living species by population explosion, industrial and technological extension, rapid urbanization hazardous effects, energy usage, and wastes products from industrial and domestic sources. Nowadays, water pollution is a considerable global issue (Anetor., 2003). Direct and uninterrupted input of pollutants into aquatic ecosystems is caused by industrial effluents. It causes long-lasting consequences on ecosystems comprising alterations in food availability and a huge risk to the self-regulating capability of the biosphere. These industrial effluents or debris contain heavy metals, polychlorinated biphenyls (PCBs), pesticides, poly-aromatic hydrocarbons (PAHs), dioxins, petrochemicals, phenolic compounds, and microorganisms (Davies., 1988). These effluents are commonly released into water bodies. Industrial effluents comprising of a higher concentration of microbial nutrients would enhance an after-growth of considerably high coliform and other microbial types. The heavy metals present in these wastes have proved to be either carcinogenic or toxic depending on the dose and time of exposure. Undeniably, the ecological balance of an environment can simply be disturbed if wastewaters from industries and residential areas are released in it without appropriate treatment (Botkin., 1998). Formerly, the availability of water supplies has been a foremost measure in towns or cities and the advancement of great civilization for a long period. Egyptian civilization prospered near the river Nile. The cities of Nigeria including Kaduna, Lagos, and Aba rely on their rivers to a greater extent. However, the race for industrialization by African countries has caused a huge release of partially treated or raw waste materials into the nearby water bodies. The development rate of treatment facilities has become slower and these facilities cannot keep pace with the rate at which the wastes are produced by the industries (Nwachukwu S.U., 1989).

Thus, a large part of the river is consumed by the industrial wastes during the dry season and results in a greater decline in the water quality. This river water causes serious risks to the users because of bacterial situations. The effluents are least diluted during the dry season which results in seasonal fluctuations of water bodies resulting in a higher concentration of pollutants (Kanu, I., Achi., 2006)

1.5 Heavy Metals in Industrial Wastewater

Heavy metals from different industries are responsible for the contamination of water resources. Techniques such as electroplating and metallic surface treatment in industries generate an unlimited amount of heavy metals such as cadmium, zinc, lead, chromium, nickel, copper, vanadium platinum, silver, and titanium (Muchie et al., 2010).

1.6 Impacts of Heavy Metals

Heavy metals are present throughout the food chain from the lowest level to the highest level including humans and their quantity is measured in parts per trillion or parts per million (Singara et al., 2011). Some heavy metals act as xenobiotics in the human body and are harmful even if they are consumed in a small concentration. Heavy metals such as Cadmium, zinc, lead, chromium, mercury, copper iron, arsenic, magnesium is considered toxic for living organisms. The higher concentration of these metals in organisms has proved to be very noxious. One of the main issues associated with these metals is the solubility as they easily get dissolve in water (Amir et al., 2014).

Though heavy metals if present in their trace quantity is very important for some natural biological process but an increase in the concentration can be harmful (Khan et al., 2013). If industrial wastewater is not treated well before discharge into a nearby water body it can have devastating impacts. Polluted water is then used for irrigation purposes. When consumed by human beings, heavy metals accumulate in human bodies and react with organic molecules such as proteins and enzymes thus altering their structure and functioning. In addition to this, heavy metals can also affect the aesthetics of the water body as they either get dissolve or deposited at the bottom of the water body (Manju, 2015). Lead, cadmium, copper, and zinc are responsible for many health impacts such as a decrease in growth, cancer, organ damage, and in severe cases, it may lead to death. Some of the metals when combining with mercury and lead can cause autoimmunity (the condition in which the immune system starts to attack its cells). It can lead to rheumatoid arthritis, damaging of the fetal brain, kidney diseases. It can also cause gastrointestinal problems and reduces blood degrees (Teixido et al., 2003).

Cadmium is responsible for renal and skeletal damage while nickel if consumed in high concentration can cause respiratory and prostate cancers and aggravates nickel dermatitis commonly known as “nickel itch” in allergic individuals. The soil, air, and water pollution are responsible for many fatal diseases and are responsible for short life expectancy (Zahid et al.,2016).

1.7 Heavy Metal Pollution Impact on Ground Water

Out of all the water resources of Pakistan, about one third is estimated to be groundwater and is a source of water supply to the municipalities. Pakistan is running dry day by day and could be waterless in the future. Industrial and commercial expansion is also responsible for the utilization of water resources and is making Pakistan a dry nation. The current water resources are vulnerable to pollution from the industries. Heavy metals, insecticides adhesives, petrochemicals, and other chemicals are responsible for water contamination. In addition to this, community dirt, ranch house, and concrete remain carried through a drainage system to rivers to increase water pollution (Riffat et al., 2009).

It is estimated that the water quality of cities such as Sialkot, Gujarat, Faisalabad, Karachi, Peshawar, Lahore, Rawalpindi, Kasur, and Islamabad has been deteriorated by the discharge of industrial and public wastewater. Groundwater contamination is considered a source of many health-related problems (Akhtar et al., 2005).

Heavy metal contamination is a worldwide issue however its intensity differs from region to region. Wastewater from industries has become an environmental concern. The common heavy metals that have been treated from wastewater are iron, copper, cadmium, lead, chromium, nickel, manganese, and zinc (WHO, 1988).

Sludge from industrial waste contains so many toxic chemicals that are harmful to the environment that is why its proper handling and disposal are important (Andra, 2012). The forms of natural limitations and their extent is subjected to the features of the geological makeup through which the groundwater flows and the quality of the recharge water. Because of various geological processes, heavy metals are naturally present in water as well. When groundwater flows through the sedimentary rocks, metals such as Zinc, Nickel, Cadmium, Chromium, Copper, and Lead mix up in the water. Industrial waste demands either proper dumping or remediation before it is discharged into the environment. Inadequate disposal of industrial waste to the surrounding may cause havoc for mankind as well the welfare resources (Ayshan, 2008)

1.8 Objectives

1. Investigation of water effluents from steel industrial and their pollution contribution to surface water reservoir.
2. Estimation of pollution load from steel units.
3. Quantitative analysis of heavy metals by preparing inventory according to the steel units.

Examine the current compliance level with industrial environmental regulations and develop a mitigation strategy for mitigation measures.

CHAPTER 2

METHODOLOGY AND PROCEDURE

Sampling and analysis were all done by following US-EPA rules and protocols while some laboratory procedures were followed by using Pak-EPA laboratory protocols as all samples were analyzed in the EPA laboratory. To crosscheck our results and for better research, some of the samples were done from EPA certified lab ES-PAK. As the study required maximum accuracy during sample collection, handling, preservation, and while performing tests in the lab so the best methods and protocols were adopted by following US-EPA guidelines.

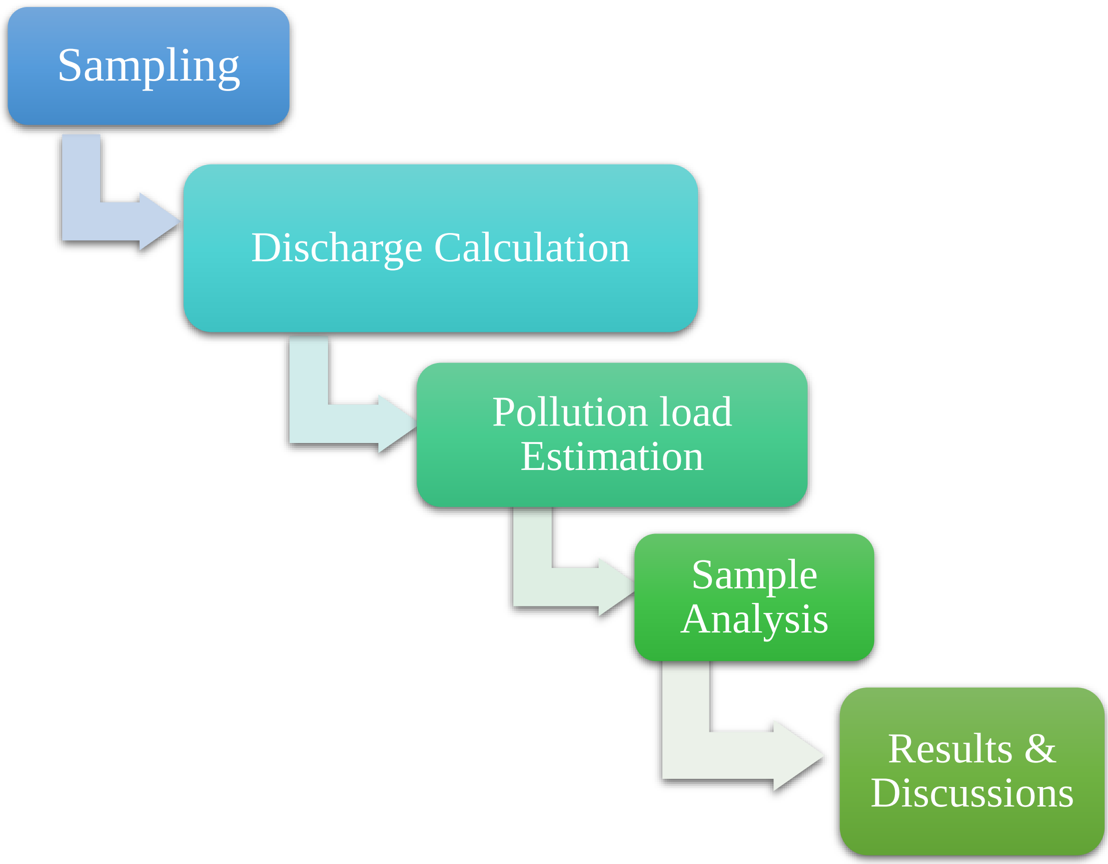


Figure 1. Research Work Flow Diagram

2.1 Study Area

Steel units were targeted on the bases of category-A industries enlisted in the PEPA Act-1997 within Islamabad territory under Zone-I. The longitude and latitude of Islamabad zone is 33.6000° N, 73.0333° E. Selected industries were shown in green dots below.

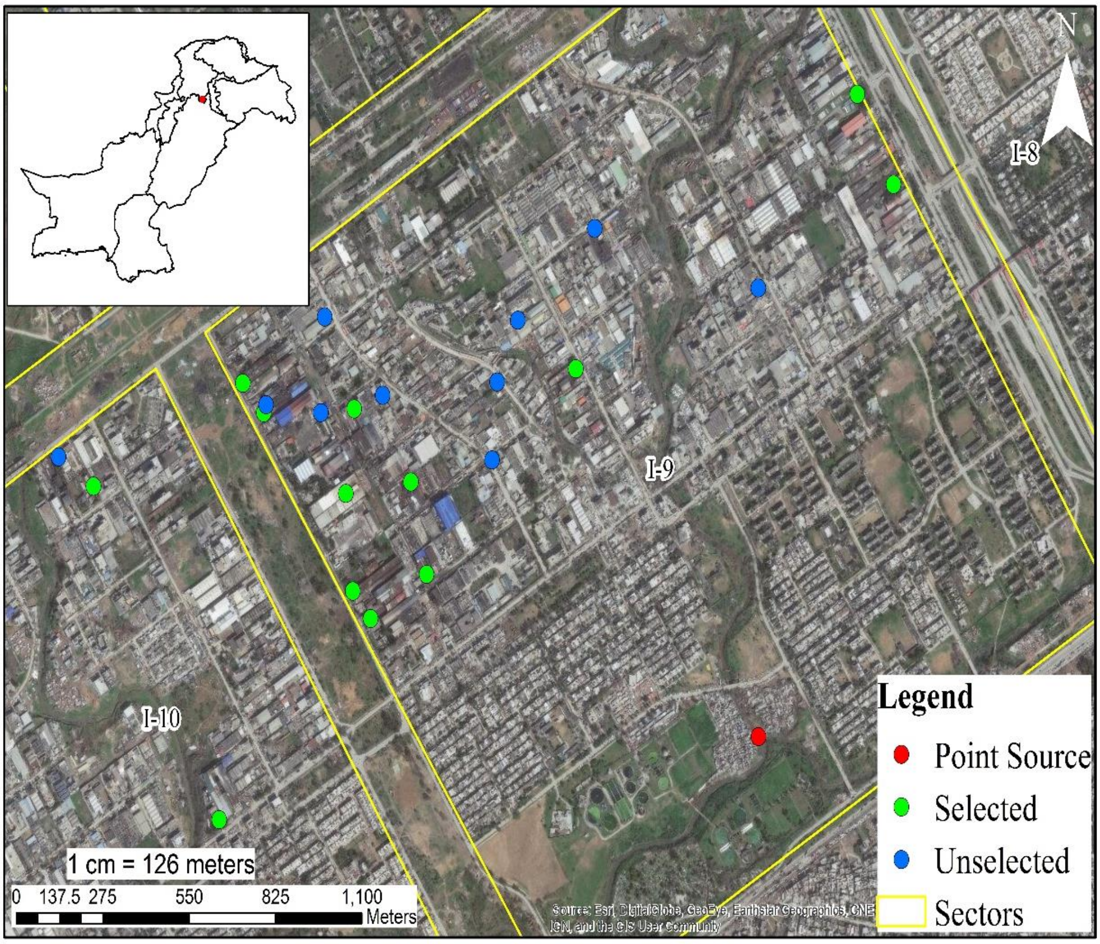


Figure 2. Study Area Location Map

2.2 Sampling Principles

Sampling is the first step to be handled very carefully for results accuracy. With proper protocols, the study is carried out very effectively. We need to be very careful as if the carried sample is the true representative sample or not. Some of the parameters were analyzed on the field so that the results would be accurate and there will be no chance of miss handling of results changing due to settling, temperature variation, sunlight or impurities might intake.

Preservatives were used according to the US-EPA method for those samples that are further being transferred for heavy metal testing on later stages.

Sampling Location		Spot Testing			Laboratory Testing						
		Temp	pH	TDS	TSS / COD / BOD / O&G	Pb	Fe	Ni	Cr	Cu	As / Zn
1	New Mustehkam Steel	●	●	●	◄	◄	◄	◄	◄	◄	◄
2	Sadiqi Steel	●	●	●	◄	◄	◄	◄	◄	◄	◄
3	MAT CAST	●	●	●	◄	◄	◄	◄	◄	◄	◄
4	Taibah Steel	●	●	●	◄	◄	◄	◄	◄	◄	◄
5	PAK Iron	●	●	●	◄	◄	◄	◄	◄	◄	◄
6	PAK Steel	●	●	●	◄	◄	◄	◄	◄	◄	◄
7	KSR	●	●	●	◄	◄	◄	◄	◄	◄	◄
8	Sarhad Steel	●	●	●	◄	◄	◄	◄	◄	◄	◄
9	MIZ Rolling	●	●	●	◄	◄	◄	◄	◄	◄	◄
10	HS Re-Rolling	●	●	●	◄	◄	◄	◄	◄	◄	◄
11	Ittehad Steel Mill	●	●	●	◄	◄	◄	◄	◄	◄	◄
12	Classic Steel	●	●	●	◄	◄	◄	◄	◄	◄	◄
13	Zia Steel(only furnace)	●	●	●	◄	◄	◄	◄	◄	◄	◄
14	Nala layi	●	●	●	◄	◄	◄	◄	◄	◄	◄

Figure 3. On and off-field testing on basses of parameters.

2.3 SAMPLING PROTOCOLS

WHO Sampling protocols were followed for sampling though out. Special training for sampling and testing was provided by Mr. Imtiaz, senior Lab Chemist in Pak-EPA. Before taking the sample rinse the bottle with the water to be sampled(thrice) and rinse the bottle cap in the same way. Collect the sample up to the top of the sampling bottles. Fill two bottles simultaneously one for physio-chemical around 1000ml and other for heavy metal analysis around 300ml. Basic parameters like Temp, TDS, pH, DO, and Total Salts on the field. Put three to four drops of nitric acid (HNO_3) for preserving samples for heavy metal analysis at pH 3 (Akomeno, 2009). Every time the sample bottle was rinsed three times from sampling water and once you are done with sampling, tight the lid and place it in an icebox that helps the sample reaching to an incubator with 4^{o}C safely. Labeling can be done on the field or maybe while placing samples in an incubator for preservation. No sample was done in bad weather(precipitation) conditions. Data collected on the field on special survey form attached in ANNEX-III.

Before leaving the Laboratory for sampling, Selection of bottles was the first step and according to protocol polyethylene plastic bottles were selected. Sampling bottles were cleaned by following laboratory SOP’s with metal-free detergent and rinsed three times with distilled water. Bottles were dripped for 24 hours in water with 20% saturation of hydrochloric acid and finally rinsed with de-ionized water and placed them in a microwave oven for 1 hour at 60^{o}c at the end and the bottles are ready.

2.4 Sampling Procedures

Twenty four(24) steel industries were targeted for effluent sampling while thirteen(13) were found functional after visiting, Some industries were only having sale storage areas but no operational production units, that were excluded from this research study. In the end, sampling was done at the point source of the Nala layi effluent stream. At every point, GPS points were collected for all 24 industries that come under the heading of Category-A of water effluent industries in PEPA Act-1997 and later targeted industries were scrutinized according to working units (i.e. 13 units). GPRS points were collected side by side and are listed below beside inventory industrial units. Sampling was carried out in July and August 2019 according to WHO & US-EPA method (AWWT, 1998).

Table.1. Coordinates of all units and a point source of Nala lai

Sr#	Industries	Lat	Long
1	New Mustehkam Steel Industry	33.658907	73.043642
2	Sadiqi Steel Industry	33.656992	73.048446
3	MAT CAST	33.656772	73.04659
4	Taibah Steel	33.664497	73.061209
5	PAK Iron	33.654881	73.0467874
6	PAK Steel	33.654347	73.047295
7	KSR	33.650454	73.042966
8	Sarhad Steel	33.658335	73.04424
9	Potohar Steel Industry	33.65849	73.044308
10	HS Re-Rolling	33.65841	73.046827
11	Islamabad Steel	33.658671	73.047642
12	RK Steel Mill	33.658332	73.045872
13	Ittehad Steel Mill	33.662756	73.062246
14	MIZ Steel Mill	33.659182	73.053166
15	Capital re-rolling	33.661902	73.053702
16	Classic Steel	33.655206	73.048895
17	ZIA	33.65691	73.039373
18	Margalla re-rolling.	33.660126	73.051508
19	Hassan Steel re-Rolling	33.660188	73.045984
20	New Al-Hillal re-rolling	33.66075	73.058378
21	Noor re-rolling	33.657419	73.050767
22	Nomee industries and re-rolling	33.658928	73.050915
23	JR Re-rolling steel	33.657477	73.038375
24	WIN re-rolling	33.652987	73.033888
25	**Nala Lai**	**33.652067**	**73.058384**

2.5 Heavy Metal & Physio-Chemical Parameters Analysis

Mainly water parameters were divided into three parts, one consisting of actual composition that does not change while observing and analyzing the sample and that comes under the category of physical parameters. No external chemicals were used to analyze samples. In this research, we included temperature, pH, TSS, and TDS. Second category consisting of chemical parameters, the actual chemical structure, and concentration changes with time or during analyzing procedures. Additional chemicals/additives were added for testing/analyzing. Chemical parameters added in the study are mainly COD, BOD, and Oil & Grease(O&G). Heavy metal is one of the most important parts to be analyzed. Because of the relatively high atomic mass of an atom, some elements are arranged under heavy metals and there even slight concentration can cause death to humans, Animals, and Aquatic life. In study seven (7) heavy metals were studied listed as lead (Pb), Iron (Fe), Nickel (Ni), Chromium (Cr), Copper (Cu), Arsenic (As), and Zinc (Zn).

As the steel industry listed in type category "A" in Schedule III of PEPA-Act, 1997. so, all these above-mentioned physio-chemical and heavy metals parameters were selected to be analyzed on priority bases as shown in the figure below.

Schedule III
[See rule 5(1)(a) and (b)]
Table A
Category "A"
Priority Parameters for Monitoring of Liquid Effluents

S.No.	Industry	Priority Parameters for Normal Plant Conditions to be Reported on a Monthly Basis[1]
1.	Chlor-Alkali (Mercury Cell)	Effluent flow, Temperature, pH, TSS, Chlorine, Mercury, Chlorides
2.	Chlor-Alkali (Diaphragm Cell)	Effluent Flow, Temperature, pH, TSS, Chlorine, Chlorides
3.	Metal Finishing and Electroplating[2]	Effluent Flow, Temperature, pH, TSS, Oil and Grease, Arsenic, Cadmium, Chromium (trivalent), Chromium (hexavalent), Lead, Nickel, Mercury, Silver Zinc, Flourides, Cyanides
4.	Nitrogenous Fertilizer	Effluent Flow Temperature, pH, TSS, Ammonia, COD
5.	Phosphate Fertilizer	Effluent Flow, Temperature pH, TSS, Cadmium, Flourides, COD
6.	Pulp and paper	Effluent Flow, Temperature, pH, COD, TSS, TDS Sulfides, BOD5
7.	Pesticides Formulation	Effluent Flow, Pesticides
8.	Petroleum Refining	Efflunt flow, Temperature,pH, COD, TSS, BOD5 Oil and Grease, phenolic compounds
9.	Steel Industry[2]	Effluent flow, Temperature, pH, COD, TSS, TDS, Chromium (trivalent), Iron, Oil and Grease, Cadium Copper
10.	Synthetic Fiber	Effluent Flow, Temperature pH, COD TSS, BOD5, Oil and Grease, Sulfides
11.	Tanning and Leather Finishing	Effluent Flow, Temperature, pH, COD, TSS, BOD5, Sulfide, Oil and Grease, Chromium (trivalent). Chromium (hexavalent), TDS, phenolic compounds
12.	Textile Processing	Effluent Flow, Temperature, pH, COD, TSS, TDS, BOD5, Copper, Chromium

Figure 4. Priority parameters of Steel Industries in PEPA Act-1997

2.6 Physio-Chemical Parameters

2.6.1 pH

pH is defined as the Potential of Hydrogen or it can be referred as power of hydrogen. It is the concentration of hydrogen ion in any solution. It refers to acidity or alkalinity of representative solution. Higher the value of H+ more will be the basic property of water, while acidic tends to the lower side of pH concentration. The pH value ranges from 0 to 14 on a pH scale.

The concentration of the hydronium ion (moles) in per liter (molarity) sowing the calculation procedure of pH. The pH is then calculated using the following expression

$$pH = -log\,[H3O+]$$

pH measurement can be helpful in calculating properties of agriculture water, wastewater from treatment plants, water in industrial processes, for environmental monitoring, development and research projects.

NEQ's limit of pH is 8.5-6.5 and 6-9 of drinking water and industrial effluents respectively. The values were calculated on filed by pH meter issued by Pak-EPA. It is a mobile meter to calculate pH on spot, which can calculate alkalinity and acidity of water samples on the field. Meter specifications are as follows.

Type of instrument	PH Meter
Company Name	Horiba
Model Number	LAQUAact PH120
Manufacture Country	JAPAN

Figure 5. On-site mobile pH meter

The pH of the samples was determined soon after sample collection through a pH meter. The meter was first calibrated before analysis. The reading was recorded by dipping the probe of the meter into the sample. The pH calculation meter by Horiba-Japan, Model Number LAQUAct pH120.

2.6.2 TDS

Water contains ions that are named as cation and anion which are calculated under the heading of total dissolved solids (TDS). These cations and anions can be of any organic or inorganic material present in water. In general, every ion and matter dissolved in mg/liter of the water sample is calculated. This parameter was also done on-field by TDS meter.

Figure 6.Onsite Mobile meter for TDS

Type of instrument	TDS Meter			
Company Name	Lovibond			
Model Number	(Senso-Dirct 150)			
Manufacture Country	Germany			
Range	200ppm	2.000ppm	20.000ppm	200ppm
Resolution	0.1ppm	1ppm	10ppm	100ppm
Accuracy	±(2%F.S+1Stelle)			

The amount of total dissolved solids(TDS) in the samples was determined through TDS meter. SensoDirect 150 by LOVIBOND-Germany was used in the study. The meter was first calibrated for error omission. The probe of the meter was then dipped in the sample and the readings were recorded.

2.6.3 TSS

TSS standards for total suspended solids which were counted as weight as the name shows they are suspended and not being dissolved in water so easily can be filtered out. Excessive count of TSS can cause sunlight obstruction in a lower stream of water ending up low oxygen level in for marine life by increasing total oxygen demand. The value was determined by the method followed below.

Figure 7. TSS filtration chamber and suction pump

Apparatus

1. Beaker
2. Filter papers
3. Incubator
4. Desiccator
5. Weight Balance
6. Vacuum pump

Wash two 100ml beakers and one what man filter paper per sample and dry it in incubator or oven. After complete drying weight the filter paper on balance and note down first weight reading. Then take a 50ml water sample in 100ml beaker and filter it with a vacuum pump using what-man filter papers. Remove the filter paper from the vacuum pump and dry it in the oven for a half-hour at 55°C. Put it into desiccator for 20 mints and weight it finally.

$$\mathbf{TSS}\,\frac{\mathbf{mg}}{\mathbf{l}} = \text{Weight final (g)} - \text{weight initial (g)} * \frac{100{,}000}{\text{volume}}\text{of sample (ml)}$$

2.6.4 COD

COD is the most popular test for wastewater samples that can be done in replacements of BOD test to calculate the concentration of organic matter. Potassium dichromate in a 50% sulfuric acid solution is used to oxidizes both organic and inorganic substances in sample, which results in a higher concentration of COD than BOD of same wastewater sample where only organic compounds were consumed during BOD testing.

- COD test takes around 2 hours to complete instead of 5-day BOD test.
- The COD test should be considered an independent measure of the organic matter in a wastewater sample rather than a substitute for the BOD test.
- The current most popular method for COD concentration in carried out by using sealed/closed reflux that was heated and solution change color from orange to green on the basis of amount of oxidation take place and that are read using a laboratory colorimeter.
- Another method was also carried out for cross check that name as NOVA 60 where specific ranged test tubes were prepared by mixing 2 ml sample of wastewater and heated for 1 hour and cooled later. While those kits were further run on NOVA 60.

Figure 8. Draft chamber for COD testing

Procedure:

Before performing COD test, a series of known standards were prepared from potassium hydrogen phthalate. Most wastewater samples usually observed in high range, so standards of 100, 250, 500, and 1000 mg/L were prepared.

1. A COD heating block and colorimeter are turned on to stabilize both instruments.
2. Based on expected results pre-prepared low-range 3-50 ppm or high-range 20-1500 ppm vessels. These ranges can be used if the expected results are unknown.

3. 2 mL of liquid is added to each vial. In the case of the “blank,” 2 mL of DI water is added. 2 mL of each standard are added to the corresponding vials. If the wastewater sample is tested at full strength, then 2 mL is added to the corresponding vial. If dilution is required, then serial dilutions are performed and 2 ml of the diluted sample was added to the corresponding vial.
4. Each vial is mixed well and placed into the reactor block for two hours. After two hours, the vials are removed from the block to a cooling rack for about 15 minutes.
5. The colorimeter is set and calibrated per the specific instructions for that unit (i.e., proper wavelength, blank, and standards) and each vial is placed in the unit and the COD concentration read.
6. If the sample was diluted, the corresponding multiplication is made.

2.6.5 BOD_5

BOD is the most commonly used test to calculate the concentration of organic matter in wastewater samples. BOD principle is based on the amount of oxygen required to consume bio waste in water. It is basically decomposition of aerobic biological organic waste by microorganisms will continue consuming oxygen (towards anaerobic environment) until all waste is consumed. The BOD test is also known as BOD_5 because of the incubation time of five days in a dark room/ area under temperature i.e., 20°C or 68°F.

Figure 9. BOD testing procedure

The aerobic biological microorganisms consumes oxygen according to biological content present and the absence of oxygen is measure in the sample.

The five-day completion time is required for this experiment as to find real time data and analyze the activity of consuming biological waste/ organic content.

Procedure:

To ensure proper biological activity during the BOD test, waste water sample must be chlorine free. If chlorine is present you can use dichlorination chemical like sodium sulfite is added before testing. Sample must be in the pH range of 6.5-7.5.

1. Specialized BOD bottles of 300ml is used and fully filled with zero air space and airtight condition are provided. The bottles are filled with the sample to be tested.
2. A DO meter is used to measure the initial dissolved oxygen concentration (mg/L) in each bottle, which should be a least 8.0 mg/L. Each bottle is then placed into a dark incubator at 20°C for five days.

3. After five days the DO meter is used again to measure a final dissolved oxygen concentration (mg/L), which ideally will be a reduction of at least 4.0 mg/L.

4. The final reading is then subtracted from the initial DO reading resulting in BOD concentration (mg/L.

5. BOD concentration reading is multiplied by the dilution factor if the sample of waste water is diluted before the test.

2.6.6 O&G

Due to highly concentrated energy content in O&G and unique physical properties it becomes a special concern in wastewater treatment. The O&G has become trendy replacing FOG (fat, oil, and grease), although both were use and represent wastewater constituents. Main constituents of O&G are lard, vegetable oils, butter, and fats etc. can come through animals and plants as well as petroleum sources like kerosene, grease and lubricating oils.

O&G usually do not mixed with water (hydrophobic characteristic) resulting in low wastewater soluble, ultimately low biodegradability by microorganisms.

High temperature tends to increase emulsion property of O&G and becomes more soluble in wastewater and often separate back from wastewater as temperature reduces so, O&G can be responsible for causing sewer assemblage problems like blockages and pump failures.

Procedure:

1. A clean flask is dried, cooled, and weighed.
2. A 1L wastewater sample is acidified (typically using hydrochloric or sulfuric acid) to a pH = 2.
3. The acidified wastewater sample is then transferred to a 2L separatory funnel.
4. 30 mL of the extraction chemical (e.g., n-Hexane) are then added to the funnel and the funnel is shaken vigorously for two minutes.
5. The wastewater/extraction chemical layers are allowed to separate in the funnel (the lighter water layer will be on the top and heavier extraction chemical layer

will be on the bottom). The bottom layer of the extraction chemical is drained into the flask prepared in Step 1.

6. Steps 4/5 are repeated twice more to extract O&G.
7. The contents of the flask (i.e., the extraction chemical containing O&G) are then heated so that the extraction chemical is distilled into another container.
8. The flask (containing the extracted O&G) is reweighed. The original weight of the flask is subtracted and the total O&G weight in mg is calculated. The results provide the O&G concentration in mg/L.

2.7 Heavy Metals

Overwhelming metals are perilous because they tend to bioaccumulate. Bioaccumulation implies an expansion in the centralization of a concoction in a natural life form after some time, contrasted with the compound's focus on the earth. Mixes amass in living things whenever they are taken up and put away quicker than they are separated (used) or discharged. Substantial metals can enter water flexibly by mechanical and shopper squander, or even from acidic downpour separating soils and discharging overwhelming metals into streams, lakes, waterways, and groundwater. Substantial metal poisonousness can bring about harmed or diminished mental and focal anxious capacity, lower vitality levels, and harm to blood structure, lungs, kidneys, liver, and other indispensable organs. Long haul introduction may result in gradually advancing physical, solid, and neurological degenerative procedures that impersonate Alzheimer's infection, Parkinson's sickness, strong dystrophy, and numerous sclerosis. Sensitivities are normal and rehashed long haul contact with certain metals or their mixes may even reason disease (Universal Word related Security and Wellbeing Centre1999). Heavy metals including Pb, Fe, Ni, Cr, Cu, As, and Zn were analyzed in samples of all units by using the Perkin Elmer Atomic Absorption Spectrometer model no (ANALYST 800) in Pak-EPA laboratory. It is hollow cathode lamps, used to observe samples. The minimum detection limits of the instrument used are Pb (15 mg/L), Fe (5 mg/L), Ni (6 mg/L), Zn (1.5 mg/L) in the flame method. Samples were aspirated through a nebulizer and the absorbance is calculated with a blank as a reference. The calibration curve was obtained using standard samples and correlation coefficients are found for each element. To keep the results in the analytical range the sample had to be diluted several times (Naikwade et al., 2012).

For testing results with good accuracy, we also applied the kit method for arsenic and test tube method and crossed checks a few samples. The pictures of both tests were attached below.

Figure 10. Test tube method for Heavy metal testing at NOVA 60.

Figure 11. Arsenic Kit testing procedure.

2.7.1 Atomic Absorption Spectrophotometric Method

In this method of AAS, aspiration of the sample into flame is done and the elements present in the sample were atomized. The light directed through flame was absorbed by the elements which were automized and is passed through a monochromator and then to the detector. The amount of light absorbed is detected by the detector, as more the light absorbed more will be the concentration of metals in the sample.

Figure 12. Sample preparation for AAS

AAS consist of Following Parts:

a) **Hollow Cathode Lamp**

A light source that emits a light spectrum of an element that you need to calculate as abortion of every element differ and on that bases the AAS works.

b) **Burner/Flame**

Premix is the most commonly known burner. The sample is evaporated by the flame of this burner that is why is known as the flam method.

c) **Monochromator**

The absorption line is displayed on the computer with help of this part.

d) **Photo Electric detector**

Every element is detected on the bases of their absorption amount and this part is responsible to measure the absorption value.

e) **Pressure reducing valves**

Fuel supply is maintained by these valves.

2.8 Flow Rate and Pollution Load Calculation

Pollution Load values were calculated w.r.t COD concentration to calculate/access the pollution mass over specific time-lapse, discharged in Nala layi (UDESC., 2019). The flow rate from each industry was first calculated and to reduce error, Discharge was calculated with a 1-hour interval, three-time from each industry. With help of 1.5-liter bottle, filling time was calculated to calculate the outflux of water. Sampling and discharge were done in days when no rain was preceded within 1.5 days.

After determining the discharge/flow rate we can determine load L according to the following equation (UDESC, 2019), and see table no.19 for the load values.

$$L = Q * C$$

While L is Load (mg/month)

Q is Discharge or flow rate (l/month)

C is concentration (mg/l)

CHAPTER 3
RESULTS & INTERPRETATIONS

Physical parameters are truly representing the position of water that can be observed physically by its smell, taste, color, turbidity, etc. while chemical parameters are named due to the addition of chemicals to make them ready for analysis in the lab.

3.1 List of Steel Industries Targeted

Results of 13 steel industries were compiled after taking a sample of their effluent from New Mustehkam Steel Industry, Sadiqi Steel industry, MAT Cast, Taibah Steel, PAK Iron, PAK Steel, KSR, Sarhad Steel, HS Re-Rolling, Ittihad Steel Mill, MIZ Steel Mill, Classic Steel, and Zia Steel. Some industrial units were closed from a long time that was not included in the study and mentioned below in questioners while the Results were tabularly as well as graphically represented besides their interpretation.

List of industries selected from an inventory made in pre-work stage.

Table.2. Inventory and selected steel industries of Islamabad

Sr#	Industries	Selected/Operational
1	New Mustehkam Steel Industry	✓
2	Sadiqi Steel Industry	✓
3	MAT CAST	✓
4	Taibah Steel	✓
5	PAK Iron	✓
6	PAK Steel	✓
7	KSR	✓
8	Sarhad Steel	✓
9	Potohar Steel Industry	✗
10	HS Re-Rolling	✓
11	Islamabad Steel	✗
12	RK Steel Mill	✗
13	Ittehad Steel Mill	✓
14	MIZ Steel Mill	✓

15	Capital Re-rolling	✗
16	Classic Steel	✓
17	ZIA	✓
18	Margalla	✗
19	Hassan Steel Re-Rolling	✗
20	New Al-Hillal re-rolling	✗
21	Noor re-rolling	✗
22	Nomee industries and re-rolling	✗
23	JR Re-rolling steel	✗
24	WIN re-rolling	✗

3.2 Physio-Chemical Results and Discussion

Results of all physio-chemical parameters are thoroughly discussed beside graphical representations and are listed in table no. 3.

Table.3. Results of physio-chemical parameters of Nala layi and Steel units.

Sr#	Industries	pH	TDS	TSS	COD	BOD	O&G
1	New Mustehkam Steel Industry	8.9	2315	921	451	168	14.5
2	Sadiqi Steel Industry	3.2	1855	642	253	48	8.7
3	MAT CAST	8.1	933	351	677	87	9.05
4	Taibah Steel	7.9	1185	211	96	28	4
5	PAK Iron	8.96	1733	749	437	61	8.73
6	PAK Steel	8.89	1655	691	172	77.5	13.9
7	Karachi Steel	9.2	1641	533	241	46	7.2
8	Sarhad Steel	8.18	3633	1143	539	284	23
9	MIZ Rolling	6.2	1921	419	188	83	8.2
10	HS Re-Rolling	7.89	1248	539	379	47	16.3
11	Ittehad Steel Mill	8.1	951	296	166	59.9	4.9
12	Classic Steel	6.8	1244	331	125	33	12.7
13	Zia Steel(only furnace)	6.91	881	107	148	37	2.91

14	Nala layi	9.9	1767	811	799	199	26.19

3.2.1 pH

pH is defined as the Potential of Hydrogen or it can be referred as power of hydrogen. It is the concentration of hydrogen ion in any solution. It refers to acidity or alkalinity of representative solution. Higher the value of H+ more will be the basic property of water, while acidic tends to the lower side of pH concentration. The pH value ranges from 0 to 14 on a pH scale.

$$pH = -\log [H3O+]$$

Reason of high Alkalinity and Acidity can be the presence of Calcium oxide, Calcium hydroxide (Lime slurry), Sodium bicarbonate, Sodium carbonate/ Soda ash, Sodium hydroxide also known as Caustic soda and Magnesium bicarbonate/ Magnesium hydroxide.

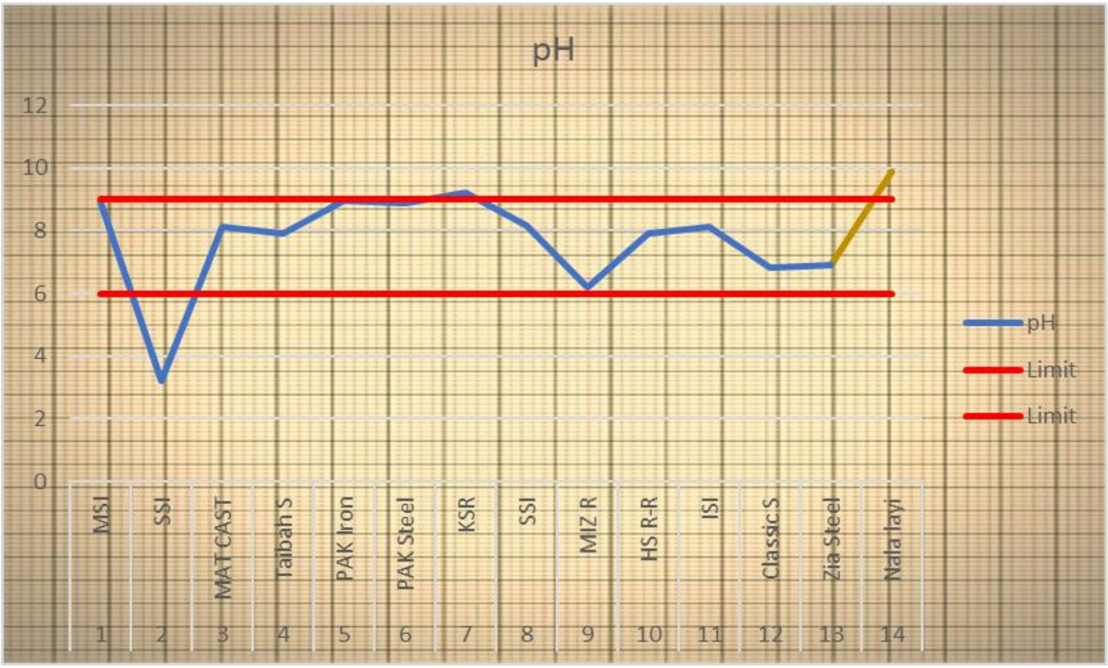


Figure 13. pH representation of 13 units and points source of Nala Layi

The results of all units were given below in table 4 with descriptive graphical representation.

Table.4. pH results of all units and Nala Layi

pH Calculation by Prob/Kit Method(on Filed)			
Sr#	**Industries**	**Calculated**	**Limit (NEQS)**
1	MSI	8.9	6-9
2	SSI	3.2	6-9
3	MAT CAST	8.1	6-9
4	Taibah Steel	7.9	6-9
5	PAK Iron	8.96	6-9
6	PAK Steel	8.89	6-9
7	KSR	9.2	6-9
8	SSI	8.18	6-9
9	MIZ R	6.2	6-9
10	HS R-R	7.89	6-9
11	ISI	8.1	6-9
12	Classic Steel	6.8	6-9
13	Zia Steel	6.91	6-9
Average		**μ = 7.795**	
14	Nala layi	9.9	6-9

Pak EPA limit for the pH of water is between 6-9. Water samples collected from 13 different steel units listed in Table 4 showed a range of pH from 3.2 to 9.2. One sample was collected from the point source of Nala lay having pH 9.9. Further, it was compared with NEQ Standards as shown in the diagram. Karachi Steel (KSR) was observed above limit range to basic side i.e. 9.2 while on Acidic side Siddique Steel was with a very low pH value of 3.2. All other industries were found between national limit values while the average value of all industries was 7.795. Nala Lay was observed high toward the basic side with pH 9.9 due to much industrial waste effluent at the point source.

The effect of acidic or basic pH depends on the strength & concentration of alkalis and acids present. The lower and higher values in specific industries were due to miss handling of chemicals used in industries. They can be corrosive if the value is on an extreme higher or lower side but dilution make them no-corrosive. pH alone is not effective on the adverse side as pH of stomach ranges 1.0 and 3.5 containing HCL while many fruits & juices contain lower or upper side pH ranges like lemon, vinegar but because of the weak base, they are not potentially harmful. As pH effect is related to other elements of water quality but it can cause corrosion and also affect the quality of disinfectant.

3.2.2 Total Dissolve Solids (TDS)

Water contains ions that are named as cation and anion which are calculated under the heading of total dissolved solids (TDS). These cations and anions can be of any organic or inorganic material present in water. In general, every ion and matter dissolved in mg/liter of the water sample is calculated. This parameter was done on the field by TDS meter. Detail results of TDS were shown in table.5 with graphical representation and description below.

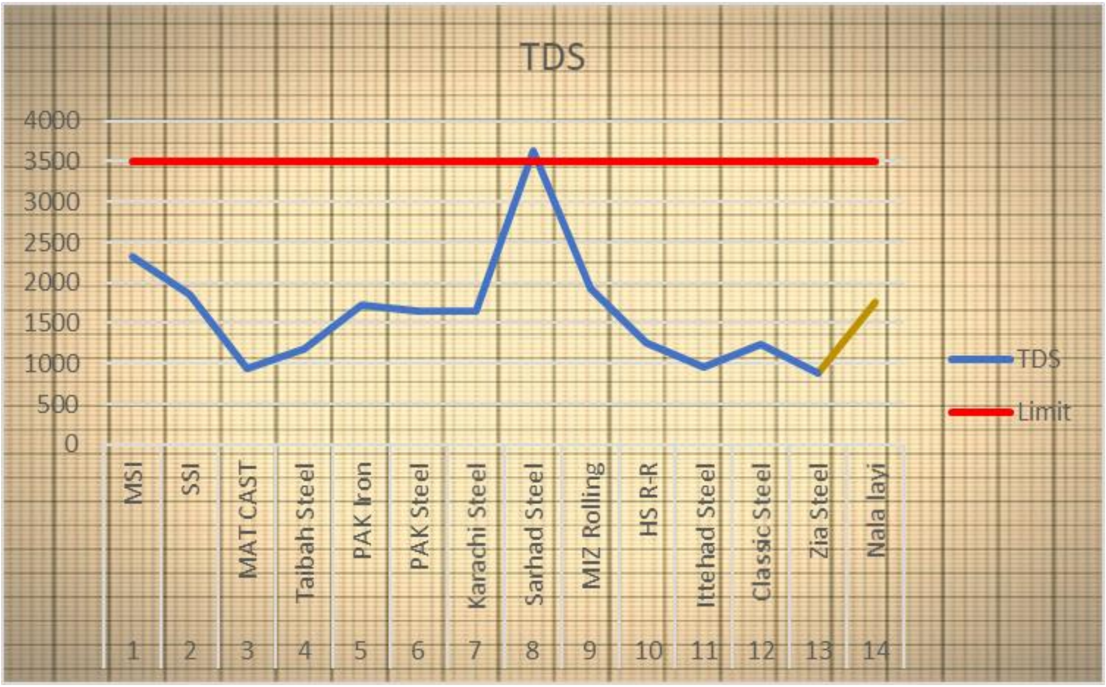


Figure 14. TDS values of thirteen units and a point source of Nala layi

Table.5. TDS results of all units and Nala Layi

Sr#	Industries	TDS	Limit
1	MSI	2315	3500
2	SSI	1855	3500
3	MAT CAST	933	3500
4	Taibah Steel	1185	3500
5	PAK Iron	1733	3500
6	PAK Steel	1655	3500
7	Karachi Steel	1641	3500
8	Sarhad Steel	3633	3500
9	MIZ Rolling	1921	3500
10	HS R-R	1248	3500
11	Ittehad Steel	951	3500
12	Classic Steel	1244	3500
13	Zia Steel	881	3500
Aaverage		**μ = 1630.38**	
14	Nala layi	1767	3500

NEQS limit for the TDS of water is 3500. Results of wastewater samples collected from 13 different steel units showed ranging from 881 to 3633. Sample collected from the point source of Nala lay having TDS 1767. Further, it was compared with NEQ standards as shown in figure 14. Tabular details of each concerning point of industries were listed above in table no.5. Only Sarhad Steel was observed with higher TDS values i.e. 3633. The overall trend of TDS is due to less dissolving capability of salts, minerals, and metals as well as the salts like potassium sulfate, calcium sulfates were not used in any process.

3.2.3 Total Suspended Solids (TSS)

Nala layi with one point source and thirteen steel units were examined for TSS. The results of all industries were remarkably high. The range of Total Suspended Solid (TSS) was observed between 107 to 1143 with the lowest from Taiba steel to highest from Sarhad steel. An average value is μ =533.308 and the values of Nala layi also high up to 811. These higher side values were due to particulates and water thrown on steel slabs from roller continuously.

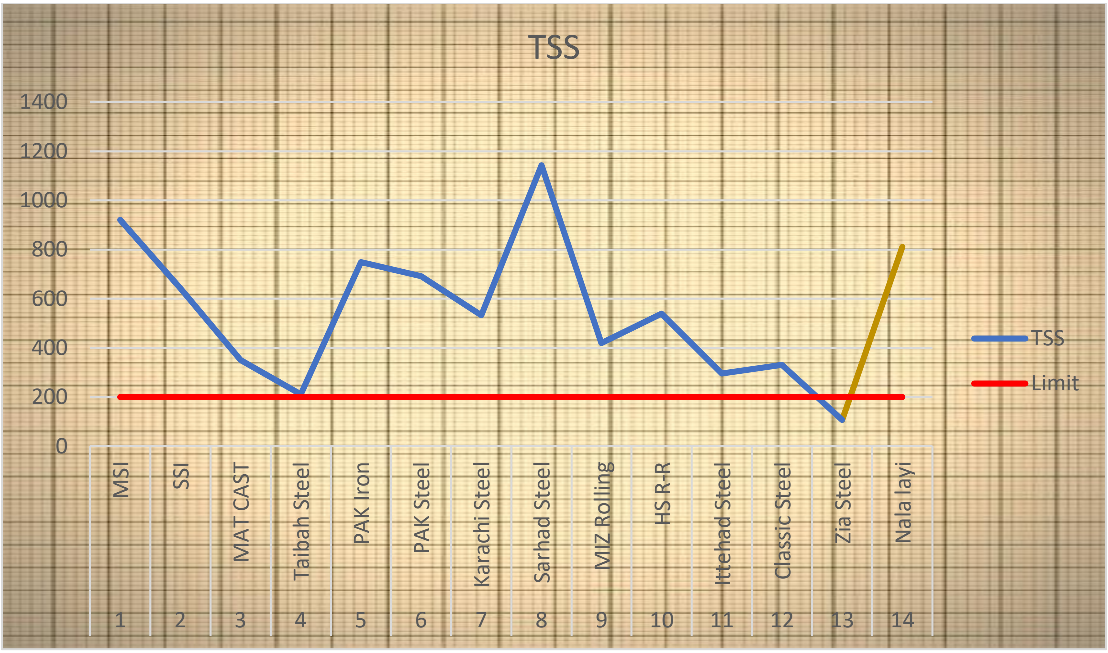


Figure 15. TSS values of thirteen units and point source of nala layi

The results also shows that no water treatment was being carried out in industry with pathetic handling of water. As high Suspended partials can reduce DO in water and kill marine life and if used in agriculture and streams can cause handling problems (Pratap et al., 2012).

Table.6. TSS results of all units and Nala Layi

Sr#	Industries	TSS	Limit
1	MSI	921	200
2	SSI	642	200
3	MAT CAST	351	200
4	Taibah Steel	211	200
5	PAK Iron	749	200
6	PAK Steel	691	200
7	Karachi Steel	533	200
8	Sarhad Steel	1143	200
9	MIZ Rolling	419	200
10	HS R-R	539	200
11	Ittehad Steel	296	200

12	Classic Steel	331	200
13	Zia Steel	107	200
Average		**μ = 533.308**	
14	Nala layi	811	200

3.2.4 Chemical Oxygen Demand (COD)

Nala layi with one point source and thirteen steel units were examined for Chemical oxygen demand. COD of only two points of Classic steel and Taiba steel were examined low i.e. 125mg/l and 96mg/l respectively. The range of Chemical oxygen demand was observed from 96mg/l to 829mg/l. MSI, SSI, MAT CAST, Pak Iron, Pak Steel, KSR, Sarhad steel, MIZ, HS, Ittihad Steel & Zia steel were observed above↑ limit i.e., 451, 253, 677, 437, 172, 241, 829, 188, 379, 166 and 148mg/l respectively with an average value of μ =320.154. while values of Nala layi was observed too high 799mg/l due to chemical. These higher side values were due to chemicals an organic matters that were oxidized in water resulting in very high COD. Excessive use of chemicals was observed throughout the process like Silver, Manganese, Black-lead, and Silicates, as metal ranges excided resulting in metal oxidation increasing COD↑.

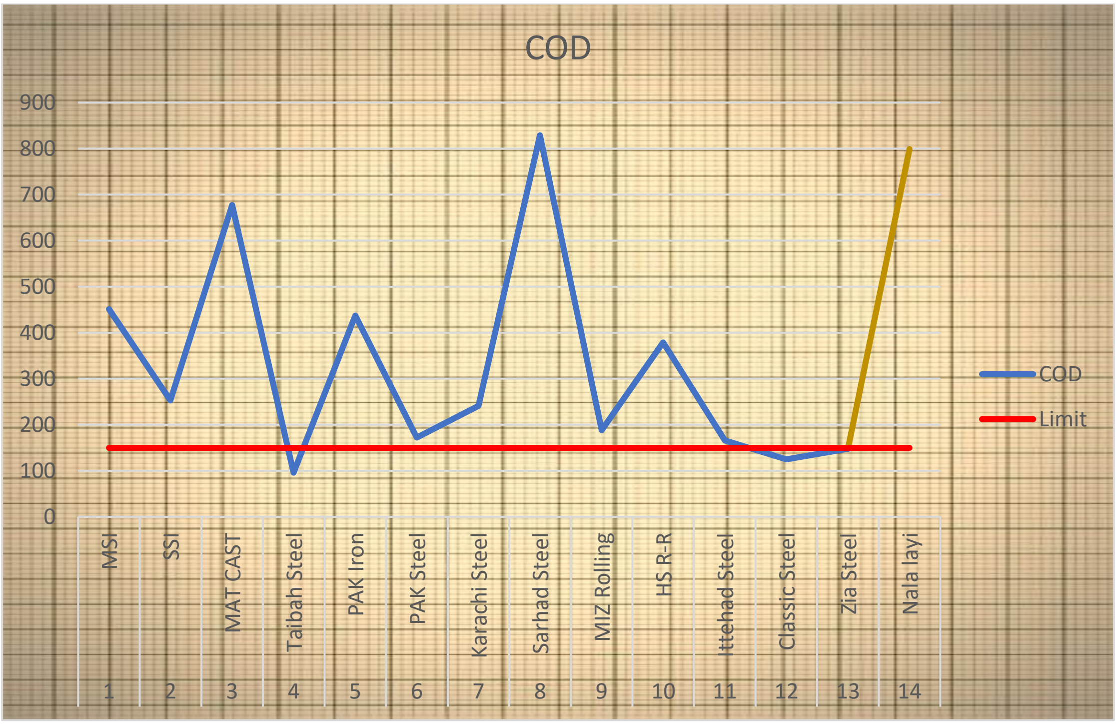


Figure 16. COD values of thirteen units and a point source of Nala layi

Table.7. COD results of all units and Nala Layi

Sr#	Industries	COD	Limit
1	MSI	451	150
2	SSI	253	150
3	MAT CAST	677	150
4	Taibah Steel	96	150
5	PAK Iron	437	150
6	PAK Steel	172	150
7	Karachi Steel	241	150
8	Sarhad Steel	829	150
9	MIZ Rolling	188	150
10	HS R-R	379	150
11	Ittehad Steel	166	150
12	Classic Steel	125	150
13	Zia Steel	148	150
Average		**μ = 320.154**	
14	Nala layi	799	150

3.2.5 Biological Oxygen Demand (BOD)

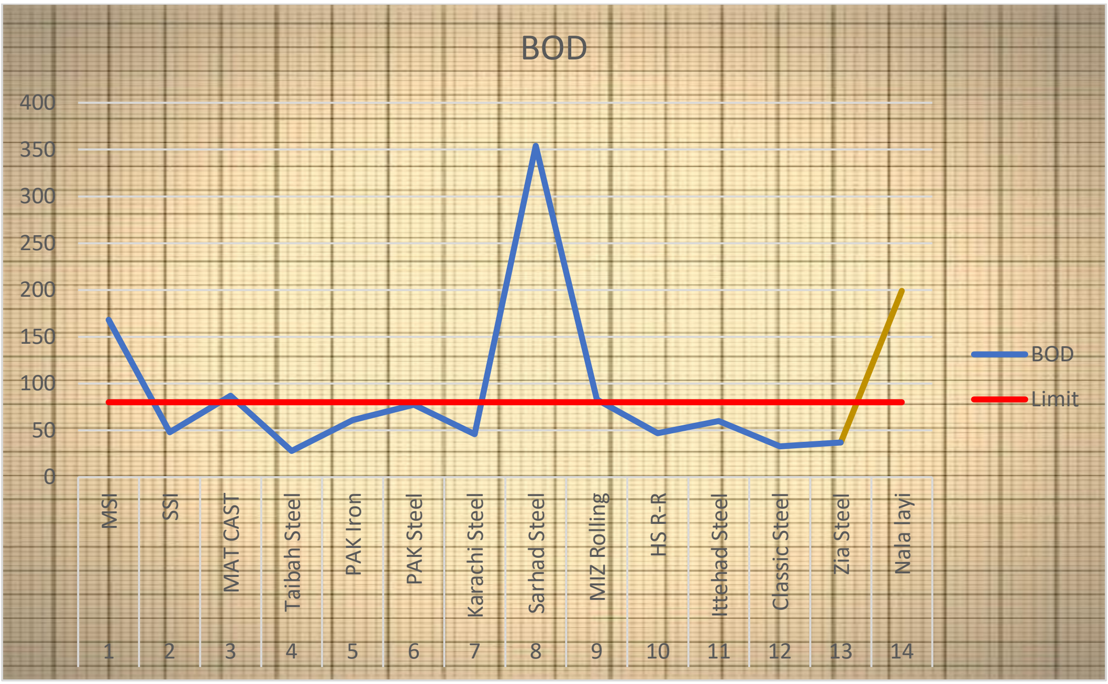


Figure 17.1. BOD values of thirteen units and a point source of Nala layi

BOD of only four points of MIS, MAT-CAST, Sarhad, and MIZ steel were exciding limits i.e. 168mg/l, 87mg/l, 354mg/l, and 83mg/l respectively. The range of biological oxygen demand was overall less with an average value of μ =86.87mg/l. while values of Nala layi were observed high 199mg/l due to the waste of other industries at a single point. These higher side values were due to the mixing of wastewater or other organic content. No immediate connection of biowaste was observed that is why the values which were lower side were not exceeding the NEQS limit.

Table.8. BOD results of all units and Nala Layi

Sr#	Industries	BOD	Limit
1	MSI	168	80
2	SSI	48	80
3	MAT CAST	87	80
4	Taibah Steel	28	80

5	PAK Iron	61	80
6	PAK Steel	77.5	80
7	Karachi Steel	46	80
8	Sarhad Steel	354	80
9	MIZ Rolling	83	80
10	HS R-R	47	80
11	Ittehad Steel	59.9	80
12	Classic Steel	33	80
13	Zia Steel	37	80
Average		**μ = 86.8769**	
14	Nala layi	199	80

3.2.6 Oil and Grease (O&G)

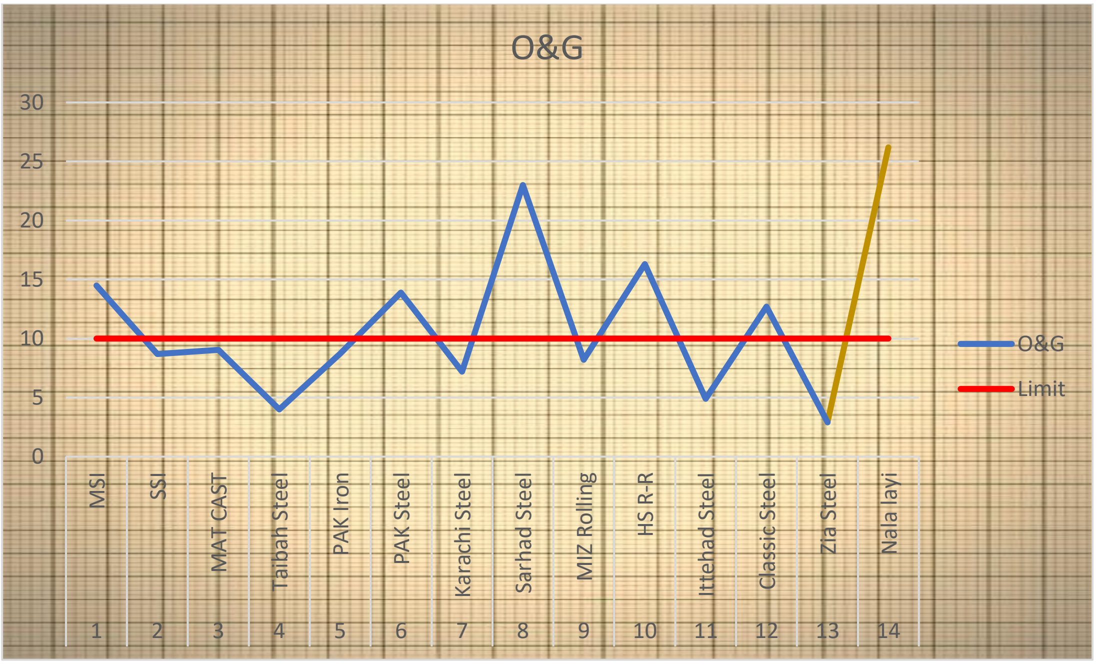


Figure 18.2. O&G values of thirteen units and a point source of Nala layi

This graph is interlinked with the quality of scrap ultimately showing oil and grease content. The graph of 5 industries has seemed high w.r.t O&G which includes MSI, Pak-Steel, Sarhad steel, HS-RR, and classic steel with concentration 14.5, 13.9, 23, 16.3 and 12.7mg/ while Nala layi source point was observed 26.19mg/l. As we move towards more local scrap, more will be the oil and grease level while shredded and HMS is imported good quality scrap with decreasing O&G results. Due to an increase in O&G, DO reduce with an increase in COD and BOD demand and threat to marine ecology.

Table.9. O&G results of all units and Nala Layi

Sr#	Industries	O&G	Limit
1	MSI	14.5	10
2	SSI	8.7	10
3	MAT CAST	9.05	10
4	Taibah Steel	4	10
5	PAK Iron	8.73	10
6	PAK Steel	13.9	10
7	Karachi Steel	7.2	10
8	Sarhad Steel	23	10
9	MIZ Rolling	8.2	10
10	HS R-R	16.3	10
11	Ittehad Steel	4.9	10
12	Classic Steel	12.7	10
13	Zia Steel	2.91	10
Average		**μ = 10.3146**	
14	Nala layi	26.19	10

3.3 Heavy Metals Results and Analysis Discussion

Results of Heavy metals are thoroughly discussed beside graphical illustrations and are listed in table no. 3.2.

Table.10. Results of Heavy Metals of Nala layi and Steel Industries

Sr#	Industries	Pb	Fe	Ni	Cr	Cu	As	Zn
1	**New Mustehkam Steel Industry**	0.156	13.08	1.53	1.51	5.77	ND	10.8
2	**Sadiqi Steel Industry**	0.188	8.81	1.92	0.98	5.02	BDL	36.1
3	**MAT CAST**	BDL	5.87	1.2	BDL	3.51	BDL	5.99
4	**Taibah Steel**	0.161	9.99	2.51	1.69	0.22	BDL	8.81
5	**PAK Iron**	0.21	9.91	3.05	2.11	1.65	0.011	9.89
6	**PAK Steel**	0.183	10.05	3.79	2.01	2.72	BDL	2.65
7	**Karachi Steel**	BDL	13.91	1.38	BDL	0.58	BDL	11.95
8	**Sarhad Steel**	0.51	11.91	1.75	5.01	4.18	0.017	8.11
9	**MIZ Rolling**	0.31	12.72	2.63	BDL	2.31	BDL	13.25
10	**HS Re-Rolling**	0.291	8.58	1.23	0.33	4.19	BDL	2.39
11	**Ittehad Steel Mill**	0.171	9.23	1.01	2.52	0.47	BDL	4.71
12	**Classic Steel**	0.219	8.11	3.37	BDL	0.71	BDL	2.88
13	**Zia Steel(only furnace)**	0.311	1.28	0.02	BDL	0.18	BDL	2.1
14	**Nala layi**	**2.17**	**3.31**	**3.2**	**1.04**	**0.31**	**0.05**	**3.52**

3.3.1 Pb

Lead is a chemical element with the symbol Pb and atomic number 82. It is a heavy metal that is denser than most common materials. Lead is soft and malleable, and also has a relatively low melting point. When freshly cut, lead is silvery with a hint of blue; it tarnishes to a dull gray color when exposed to air.

The atomic absorption spectrometric method has a relatively high detection limit in the flame mode and requires an extraction procedure for the low concentrations common in potable water. The electrothermal atomic absorption method is much more sensitive for low concentrations and does not require extraction. The inductively coupled plasma method has a sensitivity similar to that of the flame atomic absorption method.

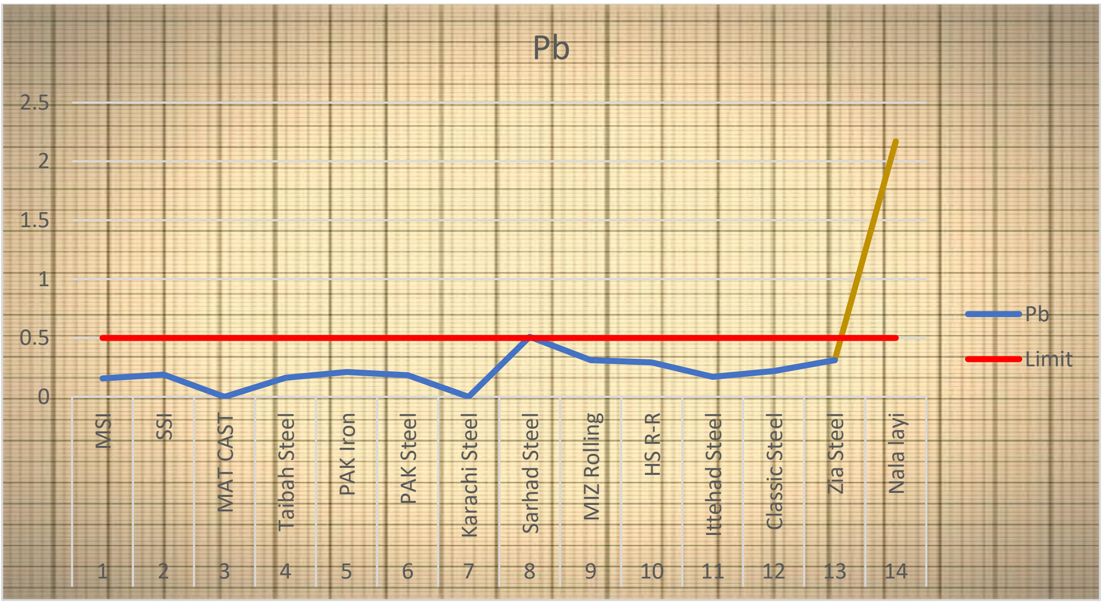


Figure 19. Pb values of thirteen units and a point source of Nala layi

NEQS allowable concentration of lead is less than 0.5 mg/l. Water samples collected, Further, it was compared with NEQ standards as shown in figure 19 from MSI, SSI, Taiba Steel, Pak Iron, Pak Steel, Sarhad steel, MIZ, HS, Ittihad Steel Classic Steel & Zia steel industry were observed and showed range less than or equal to permissible limits i.e., between 0.15 to 0.5 mg/l with an average of 0.24mg/l. MAT CAST and KSR were observed below the detection limit. The amount detected is due to the use of black lead during billets formation. Further, it was compared with Pak-EPA standards as shown in the diagram. The concentration of Nala layi was observed on a much higher side i.e., 2.17.

Table.11. Pb results of all units and Nala Layi

Sr#	Industries	Pb	Limit
1	MSI	0.156	0.5
2	SSI	0.188	0.5
3	MAT CAST	BDL	0.5
4	Taibah Steel	0.161	0.5
5	PAK Iron	0.21	0.5
6	PAK Steel	0.183	0.5
7	Karachi Steel	BDL	0.5
8	Sarhad Steel	0.51	0.5
9	MIZ Rolling	0.31	0.5
10	HS R-R	0.291	0.5
11	Ittehad Steel	0.171	0.5
12	Classic Steel	0.219	0.5
13	Zia Steel	0.311	0.5
Average		**µ = 0.24636**	
14	Nala layi	2.17	0.5

Lead is present in tap water as well as it enters through household plumbing systems. Primarily infants and pregnant women get affected by the uptake of lead. Acute toxicity of lead provokes muscle tremor, hallucinations, kidney damage, and memory loss while chronic toxicity ignites joint pain, gastrointestinal issue, and symptoms of peripheral neuropathy. According to the estimates, lead uptakes for adults were 90µg per day in Belgium and 177µg/day in Mexico. Lead ingestion also results in dysfunction of gonads in men leading to depressed sperm counts. The studies have indicated an increased risk of preterm delivery due to high exposure to lead.

3.3.2 Fe

Iron is a chemical element with symbol Fe and atomic number 26. It is a metal that belongs to the first transition series and group 8 of the periodic table. It is by mass the most common element on Earth, forming much of Earth's outer and inner core. It is the fourth most common element in the Earth's crust.

The atomic absorption spectrometric method has a relatively high detection limit in the flame mode and requires an extraction procedure for the low concentrations common in potable water. The electrothermal atomic absorption method is much more sensitive for low concentrations and does not require extraction. The inductively coupled plasma method has a sensitivity similar to that of the flame atomic absorption method.

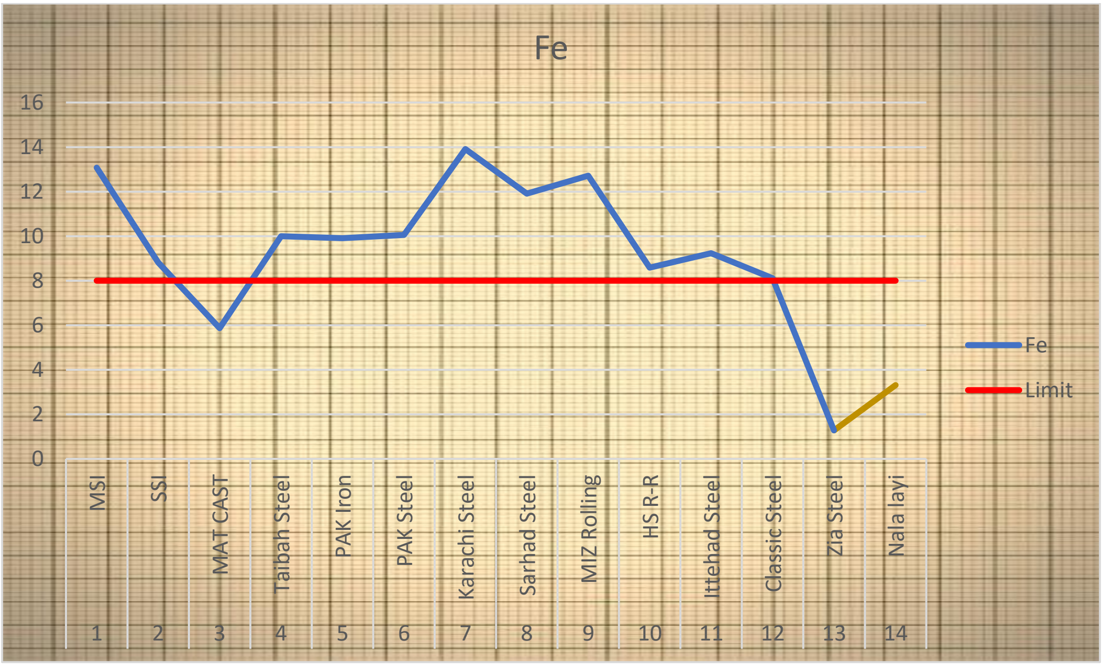


Figure 20. Fe values of thirteen units and a point source of Nala layi

NEQS allowable concentration of iron is 8 mg/l. Fe concentration of samples collected from MSI, SSI, MAT CAST, Taiba Steel, Pak Iron, Pak Steel, KSR, Sarhad steel, MIZ, HS, Ittihad Steel Classic Steel & Zia steel industry is 13.08, 8.81, 5.87, 9.99, 9.91, 10.05, 13.91, 11.91, 12.72, 8.58, 9.23, 8.11 and 1.28mg/l as shown in figure 12. The average concentration of Iron was observed μ = 9.49615mg/l. Samples were ranging high except Zia Steel i.e., 1.28mg/l because that water instead of thrown on steel bars in the re-rolling section, it was utilized by only electric induction furnace. As steel bars composition is by Fe ore minerals and water was thrown continuously on bars and rollers that is the intake of concentration source for Fe.

Table.12. Fe results of all units and Nala Layi

Sr#	Industries	Fe	Limit
1	MSI	13.08	8
2	SSI	8.81	8
3	MAT CAST	5.87	8
4	Taibah Steel	9.99	8
5	PAK Iron	9.91	8
6	PAK Steel	10.05	8
7	Karachi Steel	13.91	8
8	Sarhad Steel	11.91	8
9	MIZ Rolling	12.72	8
10	HS R-R	8.58	8
11	Ittehad Steel	9.23	8
12	Classic Steel	8.11	8
13	Zia Steel	1.28	8
Average		**μ = 9.49615**	
14	Nala layi	3.31	8

Iron is found in many of the groundwater sources. Rarely 1 mg of iron per liter as found in a normal pH range of surface water but if the level exceeds it can make the water harmful. According to research conducted in 2005, 31% higher levels of iron were found in the water system of Faisalabad, and 56% in Lahore. Iron in drinking water allows bacteria to grow and it penetrates a human body, making the person sick. It results in harmful skin conditions. High levels of iron can harm the inner organs. Extreme exposure to iron provokes diabetes which can cause liver or heart failure (WHO, 2003).

3.3.3 Ni

Nickel is a chemical element with the symbol Ni and atomic number 28. It is a silvery-white lustrous metal with a slight golden tinge. Nickel belongs to the transition metals and is hard and ductile. The atomic absorption spectrometric method has a relatively high detection limit in the flame mode and requires an extraction procedure for the low concentrations common in potable water. The electrothermal atomic absorption method is much more sensitive for low concentrations and does not require extraction. The inductively coupled plasma method has a sensitivity similar to that of the flame atomic absorption method.

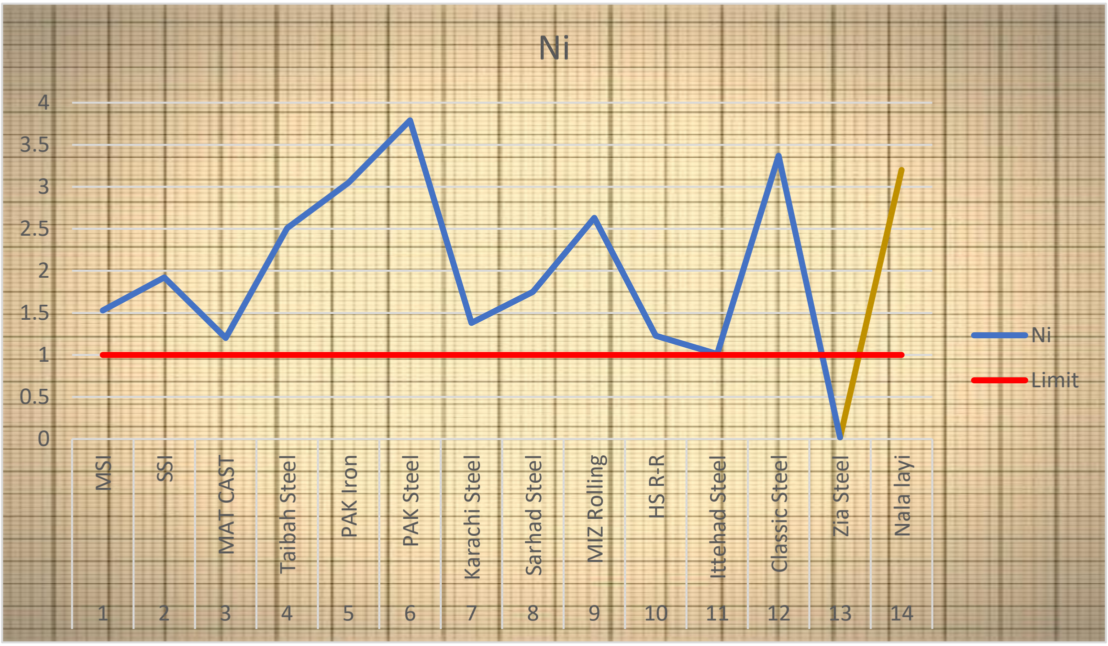


Figure 21. Ni values of thirteen units and a point source of Nala layi

The allowable concentration of WHO and Pak-EPA for Nickel is less than 1 mg/l. results of water samples collected from thirteen different steel units showed a range of Nickel from 0.02 to 3.79 mg/l as shown in table 13. Further, it was compared with NEQ Standards as shown in figure 21. Except for concentration of Zia steel industry i.e., 0.02 Nickel concentration level of all MSI, SSI, MAT CAST, Taiba Steel, Pak Iron, Pak Steel, KSR, Sarhad steel, MIZ, HS, Ittihad Steel Classic Steel were observed higher than permissible limit i.e., 1.53, 1.92, 1.2, 2.51, 3.05, 3.79, 1.38, 1.75, 2.63, 1.23, 1.01, 3.37 respectively with an average of µ =1.95308 mg/l as shown in table 13. While the level of Nickle in Nala layi source point was also exceeding from NEQS limits 3.2mg/l. As an ore mineral nickel is present in a scrap as also observed in results.

Table.13. Ni results of all units and Nala Layi

Sr#	Industries	Ni	Limit
1	MSI	1.53	1
2	SSI	1.92	1
3	MAT CAST	1.2	1
4	Taibah Steel	2.51	1
5	PAK Iron	3.05	1
6	PAK Steel	3.79	1
7	Karachi Steel	1.38	1
8	Sarhad Steel	1.75	1
9	MIZ Rolling	2.63	1
10	HS R-R	1.23	1
11	Ittehad Steel	1.01	1
12	Classic Steel	3.37	1
13	Zia Steel	0.02	1
	Average	**µ =1.95308**	
14	Nala layi	3.2	1

Excessive intake of nickel may result in harm to mucous membranes and cause alteration in chromosomes. It can even lead to the formation of cancer cells. The intake of high levels of nickel accentuates the risk of lung cancer, nose cancer, larynx cancer, and prostate cancer. Asthma and chronic bronchitis can also be caused by nickel ingestion. The major effect of high intake of nickel includes heart disorders.

3.3.4 Cr

Chromium is a chemical element with the symbol Cr and atomic number 24. It is the first element in group 6. It is a steely-grey, lustrous, hard, and brittle transition metal. Chromium is the main additive in stainless steel, to which it adds anti-corrosive properties. The atomic absorption spectrometric method has a relatively high detection limit in the flame mode and requires an extraction procedure for the low concentrations common in potable water. The electrothermal atomic absorption method is much more sensitive for low concentrations and does not require extraction. The inductively coupled plasma method has a sensitivity similar to that of the flame atomic absorption method.

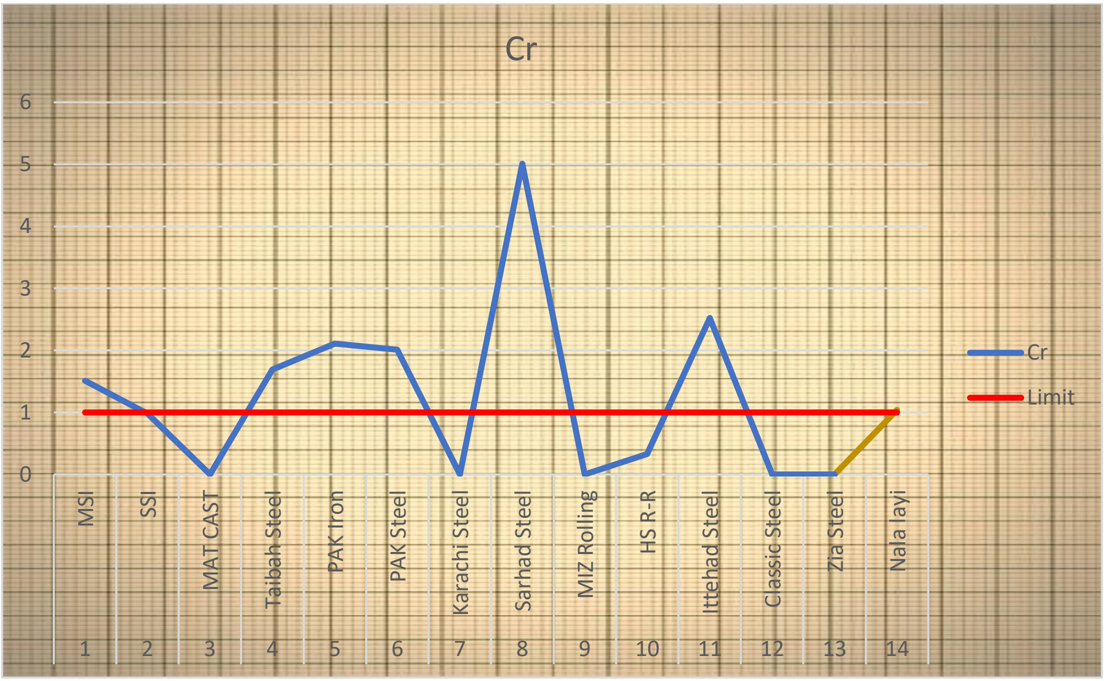


Figure 22. Cr values of thirteen units and a point source of Nala layi

The allowable concentration of WHO and Pak-EPA for chromium is less than 1 mg/l. Water samples collected from nine different steel units showed a range of chromium from BDL to 5.01 mg/l. Further, it was compared with Pak-EPA standards as shown in the diagram. Chromium level of all the industries MSI, SSI, MAT CAST, Taiba Steel, Pak Iron, Pak Steel, KSR, Sarhad steel, MIZ, HS, Ittihad Steel Classic Steel & Zia steel industry were observed from which six of units were ranging higher to permissible limits while all of the values were discussed i.e., 1.51, 0.98, BDL, 1.69, 2.11, 2.01, BDL, 5.01, BDL, 0.33, 2.52, BDL, BDL respectively with an average of 2.02 mg/l as shown in figure 15.3.

Table.14. Cr results of all units and Nala Layi

Sr#	Industries	Cr	Limit
1	MSI	1.51	1
2	SSI	0.98	1
3	MAT CAST	BDL	1
4	Taibah Steel	1.69	1
5	PAK Iron	2.11	1
6	PAK Steel	2.01	1
7	Karachi Steel	BDL	1
8	Sarhad Steel	5.01	1
9	MIZ Rolling	BDL	1
10	HS R-R	0.33	1
11	Ittehad Steel	2.52	1
12	Classic Steel	BDL	1
13	Zia Steel	BDL	1
Average		**μ =2.02**	
14	Nala layi	1.04	1

Acute exposure to high levels of chromium can cause certain health effects. Ingestion of 1g to 5g chromate results in severe acute effects such as gastrointestinal disorders, hemorrhagic diathesis, and convulsions. Diarrhea, stomach bleeding along with liver and kidney damage can be a result of chromium ingestion. Due to excessive intake of chromium, cardiovascular shock may occur

3.3.5 Cu

The atomic absorption spectrometric method has a relatively high detection limit in the flame mode and requires an extraction procedure for the low concentrations common in potable water. The electrothermal atomic absorption method is much more sensitive for low concentrations and does not require extraction. The inductively coupled plasma method has a sensitivity similar to that of the flame atomic absorption method.

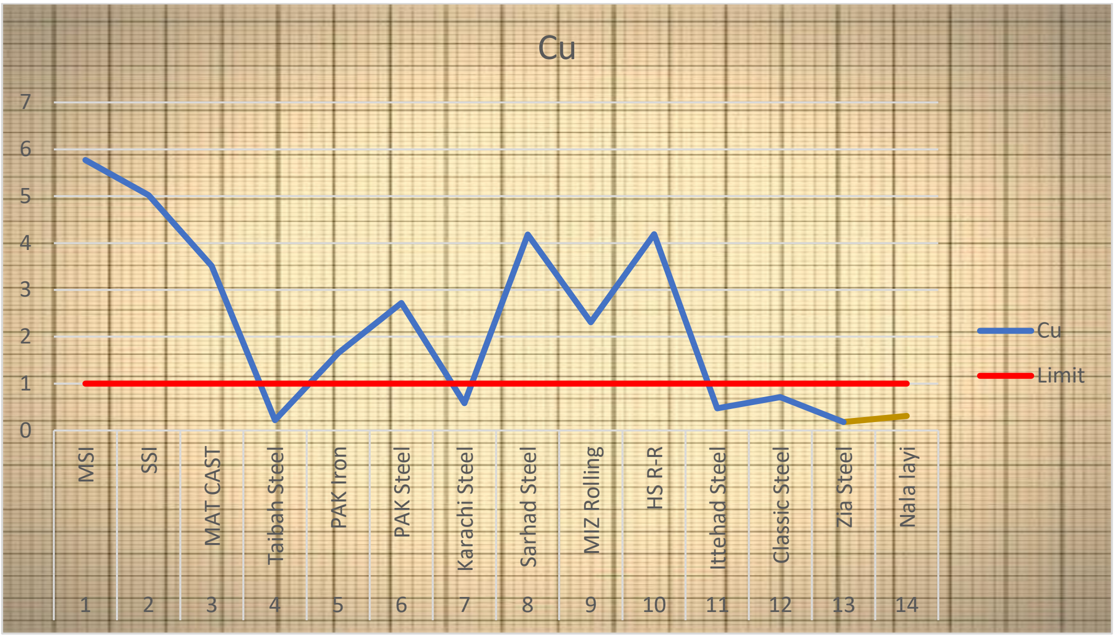


Figure 23. Cu values of thirteen units and a point source of Nala layi

Overall Chromium concentration was observed high in effluents from MSI, SSI, MAT-CAST, PAK-Iron, Pak-Steel, Sarhar Steel, MIZ, and HS-RR as 5.77,5.02, 3.51, 1.65, 2.72, 4.18, 2.31 and 4.19mg/l respectively with 5 points at low concentration. An average Cu concentration was calculated as μ =2.42385, while Nala layi was ranging low Cu concentration i.e., .31mg/l. Due to minerals and metals present in the ore, they come through scrap and water showed on bars and rollers allow them to mix and move through the water.

Table.15. Cu results of all units and Nala Layi

Sr#	Industries	Cu	Limit
1	MSI	5.77	1
2	SSI	5.02	1
3	MAT CAST	3.51	1
4	Taibah Steel	0.22	1
5	PAK Iron	1.65	1
6	PAK Steel	2.72	1

7	Karachi Steel	0.58	1
8	Sarhad Steel	4.18	1
9	MIZ Rolling	2.31	1
10	HS R-R	4.19	1
11	Ittehad Steel	0.47	1
12	Classic Steel	0.71	1
13	Zia Steel	0.18	1
Average		**μ =2.42385**	
14	Nala layi	0.31	1

Early symptoms of high uptake of copper can result in nausea, vomiting, diarrhea, and headaches. Exposure to copper for a long time is a threat to people suffering from Wilson's disease as it can damage the liver. A case report of chronic ingestion of copper demonstrates the danger of liver disorder. Animal studies have also revealed that the intake of high amounts of copper can lead to hepatic and renal diseases. Moreover, high levels of copper can damage marine life. Kidneys and nervous systems of fish and other organisms can be badly affected.

3.3.6 As

The atomic absorption spectrometric method has a relatively high detection limit in the flame mode and requires an extraction procedure for the low concentrations common in potable water. The electrothermal atomic absorption method is much more sensitive for low concentrations and does not require extraction. The inductively coupled plasma method has a sensitivity similar to that of the flame atomic absorption method.

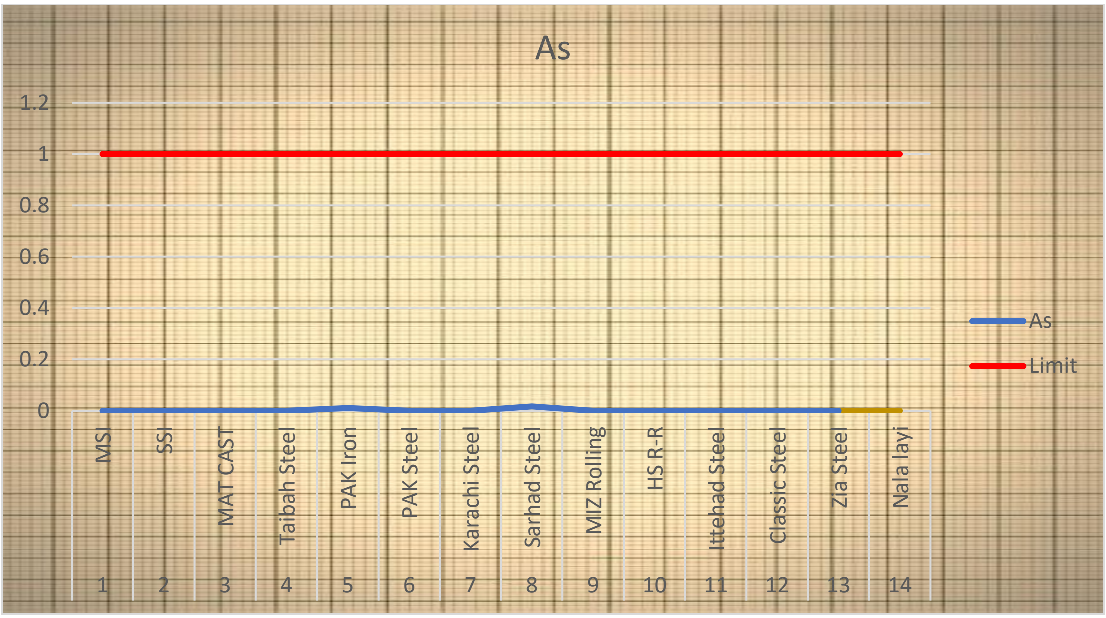


Figure 24. As values of thirteen units and a point source of Nala layi

Arsenic was low as below the detection limit. all the values throughout were lower than NEQS limits while average concentration was observed as **μ =2.42385**. Nala layi was showing the concentration of As 0.05mg/l. Arsenic concentration from Nala layi point source was due to other industries as no arsenic was detected from steel units.

Table.16. As results of all units and Nala Layi

Sr#	Industries	As	Limit
1	MSI	ND	1
2	SSI	BDL	1
3	MAT CAST	BDL	1
4	Taibah Steel	BDL	1
5	PAK Iron	0.011	1
6	PAK Steel	BDL	1
7	Karachi Steel	BDL	1
8	Sarhad Steel	0.017	1
9	MIZ Rolling	BDL	1
10	HS R-R	BDL	1

11	Ittehad Steel	BDL	1
12	Classic Steel	BDL	1
13	Zia Steel	BDL	1
Average		**μ = 0.014**	
14	Nala layi	0.05	1

Long term intake of arsenic in drinking water increases the risk of skin cancer and lung cancer. Alteration in pigmentation of the skin is also an effect of arsenic. Acute intoxication results in abdominal pain, vomiting, diarrhea, weakness, and muscular pain. Populations ingesting high levels of arsenic are likely to suffer from peripheral neuropathy and peripheral vascular disease. Long term ingestion of arsenic can cause developmental effects, neurotoxicity, and diabetes.

3.3.7 Zn

The atomic absorption spectrometric method has a relatively high detection limit in the flame mode and requires an extraction procedure for the low concentrations common in potable water. The electrothermal atomic absorption method is much more sensitive for low concentrations and does not require extraction. The inductively coupled plasma method has a sensitivity similar to that of the flame atomic absorption method.

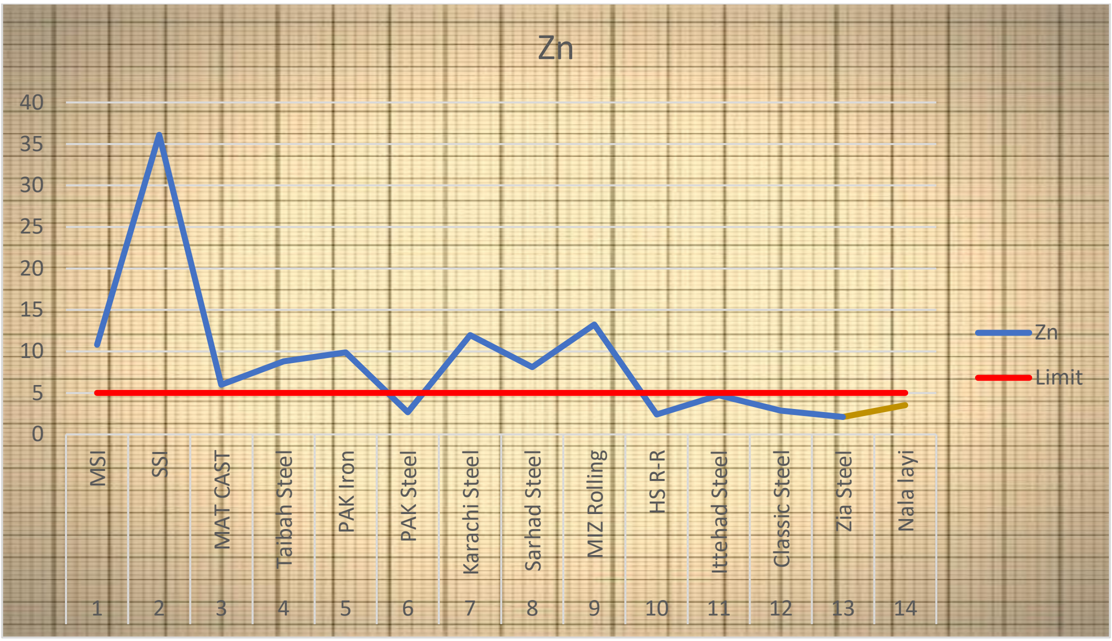


Figure 25. Zn values of thirteen units and a point source of Nala layi

Zinc concentration was observed high throughout ranging from 32.1 – 2.1mg/l with average concentration μ = 9.20231mg/l. The point source of Nala layi concentration is 3.52 mg/l. this is due to excessive local scrap usage which includes paints boxes and is likely to increase Zn concentration.

Table.17. Zn results of all units and Nala Layi

Sr#	Industries	Zn	Limit
1	MSI	10.8	5
2	SSI	36.1	5
3	MAT CAST	5.99	5
4	Taibah Steel	8.81	5
5	PAK Iron	9.89	5
6	PAK Steel	2.65	5
7	Karachi Steel	11.95	5
8	Sarhad Steel	8.11	5
9	MIZ Rolling	13.25	5
10	HS R-R	2.39	5

11	Ittehad Steel	4.71	5
12	Classic Steel	2.88	5
13	Zia Steel	2.1	5
Average		**μ = 9.20231**	
14	Nala layi	3.52	5

The central health effects caused by zinc include fever, nausea, and stomach cramps. Excessive intake of zinc even for a short time can result in diarrhea. Long time exposure to zinc causes anemia, results in the damage of pancreas, and a lower level of High-Density Lipoprotein (HDL) cholesterol. Skin irritations, disturbance in protein metabolism, arteriosclerosis, and even respiratory disorders are among the effects of high intake of zinc (WHO, 2003).

3.3.8 Pollution Load by Steel Units w.r.t Flow Rate

The flow rate of three hours was calculated with intervals of per hour so estimate the mean value of water discharge from each industry shown below in table.8.

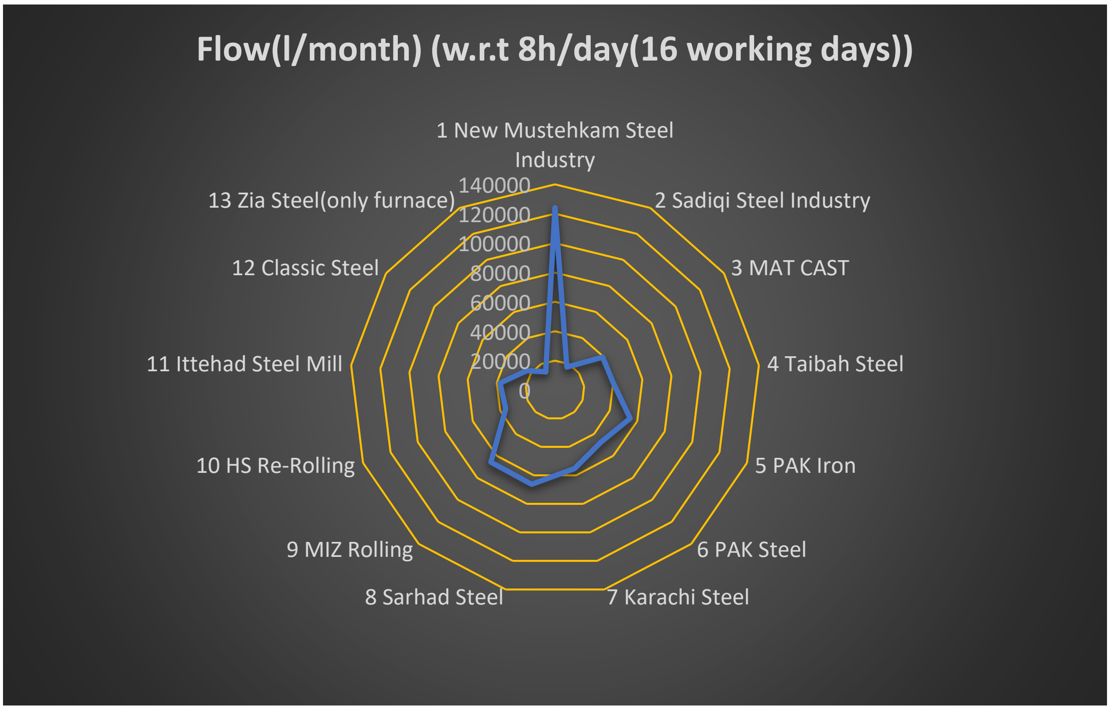


Figure 26. Water flow rate (Q)

With this flow rate estimation, you can access water usage of the steel industry sidewise, While the load of any parameters can be calculated by the discharge rate we calculated.

Table.18. Discharge rate in three hours from all units

Sr#	Industries	Coal Gasifier l/day	1st hour Flow (l/s)	2nd hour Flow (l/s)	3rd hour Flow (l/s)	Flow (l/s)	Flow(l/month) (w.r.t 8h/day(16 working days))
1	New Mustehkam Steel Industry	15000	0.21	0.25	0.25	0.2366667	124056
2	Sadiqi Steel Industry	0	0.035	0.029	0.05	0.038	17510.4
3	MAT CAST	15000	0.029	0.06	0.07	0.053	39422.4
4	Taibah Steel	15000	0.053	0.065	0.04	0.0540333	39898.56
5	PAK Iron	7500	0.083	0.125	0.1	0.1026667	54808.8
6	PAK Steel	7500	0.08	0.11	0.07	0.0866667	47436
7	Karachi Steel	15000	0.08	0.062	0.12	0.0873333	55243.2
8	Sarhad Steel	13500	0.107	0.136	0.1	0.1143333	66184.8
9	MIZ Rolling	13500	0.125	0.166	0.05	0.1136667	65877.6
10	HS Re-Rolling	10500	0.062	0.039	0.07	0.0553333	35997.6
11	Ittehad Steel Mill	12000	0.048	0.07	0.05	0.056	37804.8
12	Classic Steel	12000	0.025	0.029	0.02	0.0243333	23212.8
13	Zia Steel(only furnace)	0	0.008	0.013	0.01	0.0106667	13824
Total Flow (per month)							**µ = 621276.96**

Total Flow from steel industrial units was calculated as 621276.96 liters/month. Pollution load values were calculated on the bases of industrial discharge rate that is calculated to access the pollution mass over specific time-lapse, discharged out to every unit (UDESC., 2019).

Table.19. Pollution Load of each unit w.r.t COD

Sr#	Industries	COD (mg/l)	Flow (l/Month)	COD Load (mg/month)
1	New Mustehkam Steel Industry	451	124056	55949256
2	Sadiqi Steel Industry	253	17510.4	4430131.2
3	MAT CAST	677	39422.4	26688964.8
4	Taibah Steel	96	39898.56	3830261.76
5	PAK Iron	437	54808.8	23951445.6
6	PAK Steel	172	47436	8158992
7	Karachi Steel	241	55243.2	13313611.2
8	Sarhad Steel	829	66184.8	54867199.2
9	MIZ Rolling	188	65877.6	12384988.8
10	HS Re-Rolling	379	35997.6	13643090.4
11	Ittehad Steel Mill	166	37804.8	6275596.8
12	Classic Steel	125	23212.8	2901600
13	Zia Steel (only furnace)	148	13824	2045952
Total Sum		**4162**	**621276.96**	**μ = 228441089.8**

After determining the discharge/flow rate we can determine load L according to the following equation (UDESC, 2019), and see table no.9 for the load values.

$$L = Q * C$$

While F is Load (mg/month)

Q is Discharge or flow rate (l/month)

C is concentration (mg/l)

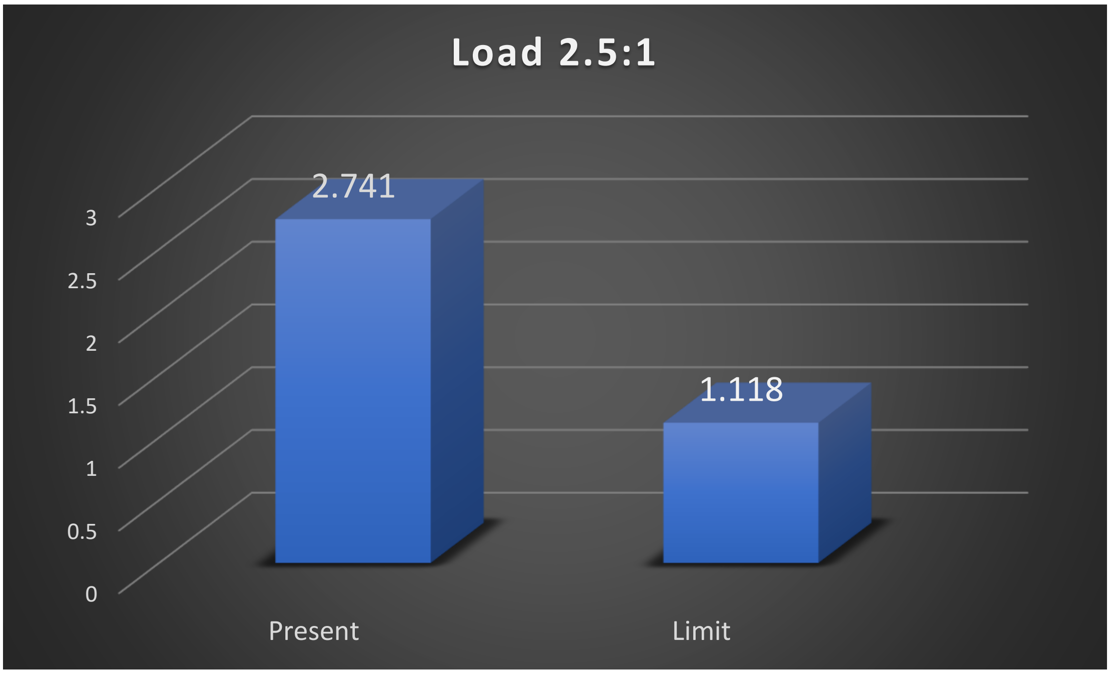


Figure 27. Pollution Load and ratio w.r.t COD

It is calculated that from around 621276.96 litter per month of discharge from steel units, the total load of all industries was summarized by "TL" Sum of the load from "n" number of steel units i.e., around

TL = 228441089.8 (mg/ month)

TL = 2,741,293,077.6 (mg/year)

TL = 2.741 (ton/year)

COD load Limit= 1.118 (tons/years)

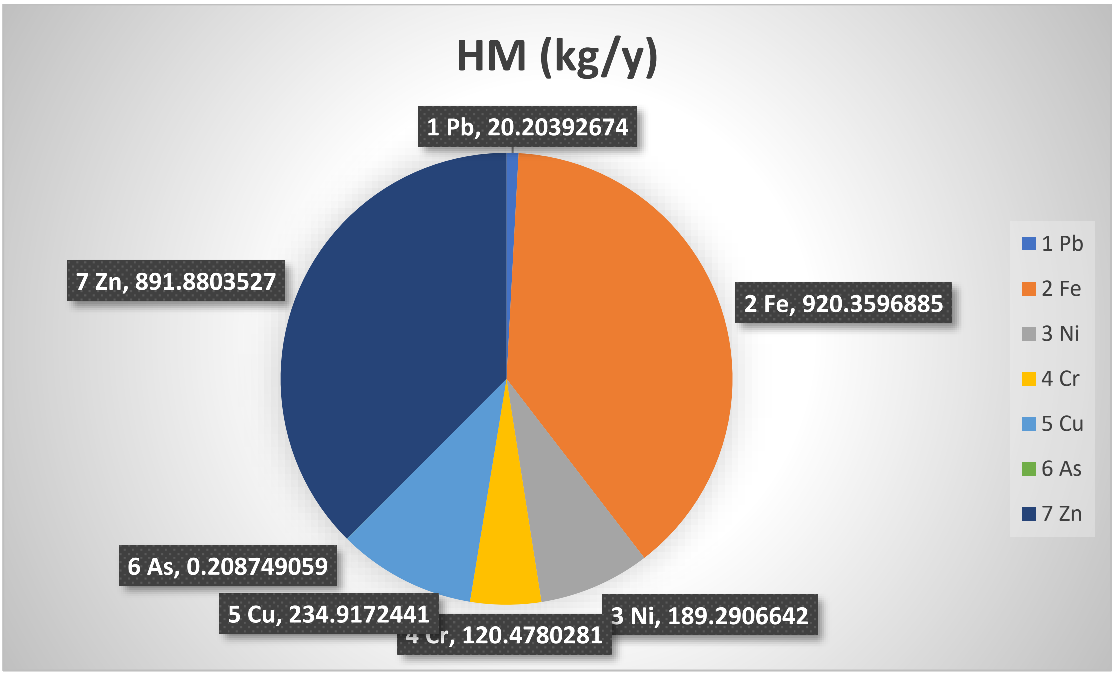
Pollution ration = 2.5:1

3.3.9 Heavy Metal Outflux

After results calculation, On the bases of water flow and discharge rate we build an inventory of heavy metals coming out from steel industries per year.

Sr	*HM*	*HM(mg/l)*	*Flow(L/year)*	*HM(mg/year)*	*HM (kg/y)*
1	**Pb**	2.71	7455323.52	20203926.74	20.20392674
2	**Fe**	123.45	7455323.52	920359688.5	920.3596885
3	**Ni**	25.39	7455323.52	189290664.2	189.2906642
4	**Cr**	16.16	7455323.52	120478028.1	120.4780281
5	**Cu**	31.51	7455323.52	234917244.1	234.9172441
6	**As**	0.028	7455323.52	208749.0586	0.208749059
7	**Zn**	119.63	7455323.52	891880352.7	891.8803527

Heavy metals were calculated in terms of per year effluents as Pb = 20.20392674, Fe = 920.3596885, Ni = 189.2906642, Cr = 120.4780281, Cu = 234.9172441, As = 0.208749059 and Zn = 891.8803527 kg's per year.



CONCLUSIONS

It was observed and concluded that steel units are majorly contributing to the pollution level of Nala layi with a ratio of around 1:2.5. Some of the major parameters like TSS and COD were out that are used to access the pollution load of industries. The major problem in steel units is the pollution contribution of the coal gasifier plant while no treatment plant/ procedure is used before allowing effluents to spill out. Hot water is another issue that increases freshwater demand to save rollers in the re-rolling section, which is controllable by using cooling towers that will end up in less water discharge, ultimately less pollution load contribution in Nala layi. It was also observed that even ISO certified units were not complying according to government's SOPs and fake and tempered results were being submitted to Pak-EPA in response to compliance.

RECOMMENDATIONS

The following economical suggestions and technical techniques can be applied to reduce discharge, water load, and water pollution of steel units.

1. Shift the coal gasifier plant into rotary plant technology. That will reduce water load/pollution and water discharge from steel units.
2. Introduce water Colling tower and recycle procedure to reduce water usage which will ultimately reduce discharge from steel units.
3. The secondary treatment plant will be more effective and is recommended on basis of results to reduce COD and TSS levels.

All steel industries can collectively or individually make water treatment plant before discharge in Nala layi.

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ANNEX-I

National Environmental Quality Standards (NEQS) For Industrial Effluents

Sr#	Parameters Standards	Standards
1	Temperature	40°C
2	pH value (acidity/basicity)	6-10 pH
3	5-days Biochemical Oxygen Demand (BOD) at 20°C	80 mg/L
4	Chemical Oxygen Demand (COD)	150 mg/L
5	Total Suspended solids	150 mg/L
6	Total dissolved solids	3500 mg/L
7	Grease and oil	10 mg/L
8	Chloride (Cl)	1000 mg/L
9	Fluoride (F)	20 mg/L
10	Cyanide (CN)	2 mg/L
11	Sulphate (SO4-2)	600 mg/L
12	Sulfide (S)	1.0 mg/L
13	Ammonia (NH3)	40 mg/L
14	Pesticides, herbicides, fungicides and insecticides	0.15 mg/L
15	Cadmium	0.1 mg/L
16	Chromium	0.1 mg/L
17	Copper	0.1 mg/L
18	Lead	0.5 mg/L
19	Mercury	0.01 mg/L
20	Solenium	0.5 mg/L
21	Nickel	1.0 mg/L
22	Silver	1.0 mg/L
23	Total toxic metals	2.0 mg/L

ANNEX-II

US-EPA and WHO standards for drinking water

Contaminants	**U.S.EPA** (mg L^{-1})	**WHO** (mg L^{-1})
Color	Colorless	Colorless
Odor	Odorless	Odorless
Taste	Tasteless	Tasteless
Temperature ^{o}C	---	$12^{o}C$
PH	6.0-8.5	6.5-9.2
DO	4-6	3 ppm
TDS	500 ppm	500
TSS	0-5	5
Cl-	250	200-500
Sulphates	250	200-400
Nitrate/Nitrite	100	45
Calcium	100	100
Magnesium	30	150
COD	4.0	10
Sodium	20	200
Potassium	---	12
E.C	300	400
Arsenic	0.05	0.05
Cadmium	0.01	0.05
Fluoride	2.2	1.5
Mercury	0.002	0.001
Iron	0.3	0.3

ANNEX-III

Steel Industrial Survey Form Serial# 3740515590921

General Information			
Industry Name		Focal Person	
Location		Contact	
Type			
Address			
ISO Certified		Scrap Quality	
Production size		Production time /day	

Water Information			
Boring or Supply		Boring water consumption amount	
Water for drinking		Water tests	
Water treatment process(if any)			
Effluent flow rate			

Coal Gasifier Plant					
Fuel type		Quantity of fuel	Per D ( )	Per M ( )	Per Y ( )
Water amount		Plant Size			