IMPACT ASSESSMENT OF EFFLUENT FROM KOTRI INDUSTRIAL SITE AREA ON ENVIRONMENT (A CASE STUDY)

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ABSTRACT: *The fresh water is important for survival of humanity and ecosystem. It is being continuously degraded due to the development of industrial sector and over-exploitation of resources. The polluted water of surface and groundwater is consumed by humans, terrestrial and aquatic life which damages their existence. Pakistan being the signatory of Millennium Development Goal (MDG) and the WTO, to provide safe drinking water to its people while managing sustainable environment to make its exportable product as per standard specifications (ISO 1400). In order to keep the quality of irrigation and drinking water safe and proper management of environmental per the standard; it is a legal binding of the industrial sector to manage safe disposal of impurities and prevent environment degradation.*

Sindh Industrial Trade Estate established in 1968 in Kotri town area is generating large volume of untreated wastewater into depression and drains which ultimately disposes off into fresh waterways, namely K.B Feeder Canal resulting degradation of environment. In order to assess the quality of wastewater, the research study was carried out on effluent which generates from various locations of SITE area of 1875 acres at Kotri town within the Indus Basin. The total of 5 sampling sites was selected in the study area which receives effluent generated by different types of industries. The results of the study reveal that this wastewater was highly contaminated with high BOD5, COD, TSS and TDS above the safe limit of NEQS which may deteriorate groundwater, surface water and agricultural fertile lands nearby the populated area The other chemical parameters such as ortho-phosphate sulphate, hardness and Magnesium indicated concentration below the admissible limit of NEQS in 4 out of 5 sampling sites. The chloride exhibited higher contamination in 2 out of 5 sampling site than the safe limits, whereas the concentration of sodium was found higher than the admissible limit of NEQS in all sampling sites. In addition, inorganic solids such as Cr, Cu, Fe, Ni, Zn, Co which are potentially toxic indicated low level of concentration than the level permissible in NEQS. Further analysis indicated that the pH was higher in 2 out of 5 sampling sites. The results further revealed that if the highly contaminated waste water is allowed without treatment, it will pose great threat to the groundwater, agriculture, aquatic life and environment. Therefore it is obligatory as per international accord and environmental law of Pakistan to control the contamination of untreated wastewater through primary treatment by providing trickle filter for removing biological and metallic impurities as well as safe disposal in depression and evaporation ponds eventually.

Keywords: Industrial Effluent, KB Feeder Canal, SITE area, NEQS,

INTRODUCTION

Industry has a key role to play in reconstruction and development. However it contribute to higher levels of natural resource exploitation and increased levels of pollution and waste with negative impacts on the environment and human health [1].

In Sindh province of Pakistan, industries are developed in an around the urban centers. One such area is located at latitude 25^o 25’ 51” N and longitude 68^0 16’ 37” E in Kotri covering an area of 1875 acres and 167 numbers of plots established in 1968. Out of 78 units, 68 are operational. These units include Textile (Spinning and Dyeing), Soap and Detergent, Electrical cables, Paper and Pulp, Ghee Plants, Flour mills, Particle size hard board, Tobacco and Cigarette, Cotton wastes and Electrical Conductors etc. Like other SITE areas of the province, there is no any treatment plant and appropriate disposal system exists; therefore, wastewater generated by all of the Industrial units is ultimately being disposed off in the water ways without any treatment.

There is no any sewerage network system in SITE area, which may collect the storm water and wastewater and convey to any appropriate disposal system. Altogether all Industrial units drain out their effluent to open drains and indiscriminate disposal of Industrial wastewater into depressions, which ultimately flows into K.B. Feeder Canal, a source of drinkable water for the citizen of Thatta and metropolitan Karachi as well as agricultural lands under its command area. Industrial wastewater is mostly containing load of metals, therefore requires proper treatment and filtering before its discharge into water bodies.

Industrial wastewater contains toxic chemicals. It is alarming that most industries have been started without proper planning and waste treatment plants. They just dispose off untreated toxic waste into nearby drains, canals or rivers. In addition, urban area also contributes major pollution loads into their water bodies. The growing urbanization has degraded the surface water quality by mixing up of industrial and municipal effluents of water bodies [2]. The uncontrolled disposal of industrial effluents and other wastewater contribute greatly to the pollution of fresh waterways [3]. And even increasing contamination load in fresh waterways increase the nutrient level of water [4].

Along with fast growth in industrial activities may lead an increase or occurrence of degradation in the surrounding environment by industrial effluents [5]. Almost fresh water waterways/rivers flowing in urban areas at the end of effluents discharged if not treated and controlled can pollute the groundwater [6].

The untreated effluents from industries are disposing off into waterways that make poor water quality which was used by humans and aquatic organism [7]. The industrial effluent disposing off without treatment into waterways is major pollution problem in the global context [8]. The surface and ground water is being polluted by various sources but the careless disposal of industrial wastewater may cause of deteriorating of fresh water quality. Almost the fresh water bodies in the areas of the developing world are the end points of effluents discharged from industries.

Presently, the most degraded part of the environment is the water resources. It is indicated that almost industries do not have wastewater treatment plants, even where installed treatment plants are poorly constructed and designed [9]. The degraded water quality is associated with the discharge of municipal effluents, industrial and agricultural wastewaters into water bodies. The water bodies lose their attractiveness and beauty due to increasing level of contamination in the water bodies [10].

Contamination is serious issue as 70% of surface water resources and as increasing number of its groundwater reserves have been degraded through biological, inorganic and organic pollutants [11]. The changes in water quality may lead to adverse impacts to humans and aquatic life. Chemical and physical parameters not only reflect abnormal impact on aquatic biota but also water quality [12]. Hence, the availability of fresh water quality have played significant role in determining the quality standard of life and it have closely linkage to water resources use and the state of economic development [13].

Water contamination is commonly enumerated as chemical, physical or biological changes in water quality which pose blight effect on the living environmental ecosystem or makes a water resource unfit for uses [14]. Pakistan has made major progress in providing access to water supply but issue of safe drinking water according to WHO and National standards is still in question, as a signatory to the Millennium Development Goal [15]

According to source, 9000 million gallons of wastewater having 20,000 tons of BOD5 loading are daily discharged into water bodies from the industrial sector [16]. The result of research studies on Industrial estates revealed some alarming warnings that indicated serious threats to the aquatic, terrestrial, atmospheric ecosystems and to the well-being of human, plant and animal life [17].

It has been reported by WHO that 25-30% of all hospital admissions are connected to water borne bacteria and parasitic conditions, with 60% of infant deaths caused by water infections. The long-term effects on human health of impurities and other pollutants include colon and bladder cancer, miscarriage, birth defects, deformation of bones, and sterility. Contamination of fresh water with radio nuclide, which can result from mining, testing, disposal and manufacturing of radioactive material, as well as transportation accidents, has led to increased incidences of cancer, developmental abnormalities and death [18].

Reuse of waste water may reduce cost of developing treatment plants. The use of reclaimed wastewater by industry is a potentially large market in developed as well as in developing and rapidly industrializing countries. Industrial reuse is highly cost-effective for industries where the process does not require water of potable quality and where industries are located near urban centres where secondary effluent is readily available for reuse [19].

RESEARCH STUDY DESCRIPTION

The research study area is located at an altitude 25° 20' 41.39" N and longitudinal 68° 16' 33.46" E (Fig. 1). The area of research study focused on the Industrial units of SITE covering an area of 1875 acres where the problem of untreated wastewater exists, and it is being dispose off into the K.B Feeder canal and nearby agricultural lands. Table 1 presents the detail of industrial units in Kotri SITE zone area.

Fig.1 Study area (Imagery map of Kotri SITE Zone area)

Table – 01: Presents the Detail of Industrial Units in Kotri SITE Zone Area

S. No.	Category of Industrial Unit	Number of Industrial Units
1	Textile (Spinning & Dye)	49
2	Paper and Pulp	08
3	Cigarettes and Tobacco	05
4	Atta Chaki/Flour Mills	08
5	Wood Work	03
6	Vegetable Oil	02
7	Oil Mills	04
8	Soap and Detergent	02
9	Ice Factory	03
10	Steel Pipes	01
11	Cotton Jinning	01
12	Cotton Waste	07
13	Electrical wires and conductors	02

METHODOLOGY FOR SAMPLES COLLECTION AND ANALYSIS

Standard sampling procedures were followed at each site to ensure the integrity of the samples collected & validity of test results prior to sampling & laboratory testing. The study is based on knowing the Industrial units operating and generating wastewater from their processes. The wastewater generates from 68 units spreading in nine open drains and their water is accumulated in mainly three depressions. Five composite sampling points were selected which represents majority of Industrial units. The samples of effluents were collected in clean polyethylene bottles and transported to the laboratory of Pakistan Council of Research in Water Resources (PCRWR) which is located at Drainage and

Relamation Institute of Pakistan (DRIP), Tando Jam for analyses. The pH and temperature were recorded at site and other parameters were investigated in the laboratory.

Collection of Samples

Five locations selected for collection of the samples represent almost 90% of the Industrial units of the SITE area and their locations are given in Figures 2 to 6.

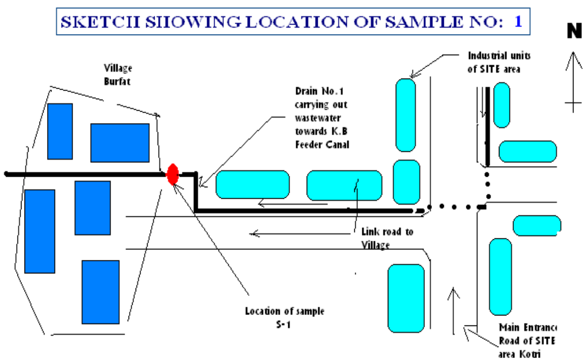

Fig. 2: Location of Sample No: S-1

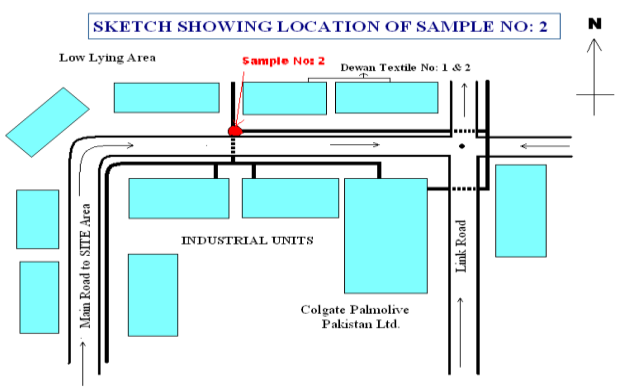

Fig. 3: Location of Sample No: S-2

Location of **Sample No. S-1** was indicated with red color (Figure.2) is the open drain (earthen), which carries about 40% of the effluent of the industrial units. This drain is crossing through the village Burfat which is situated on the east side of the SITE area boundary.

Location of **Sample No. S-2** (Fig. 3) was at the outfall of open drain (lined) which flows towards the open area (local depression) at the turning point of Dewan Textile mills No. 2 in the SITE area.

Sample No. S-3 (Fig. 4) was located at the middle point of open drain (lined) which flows towards the combined drain near M/s Atlas cables industrial unit in the SITE area.

Sample No. S-4 (Figure.5) was located at the outfall of open drain (earthen) which flows towards the local depression in the south of the SITE area.

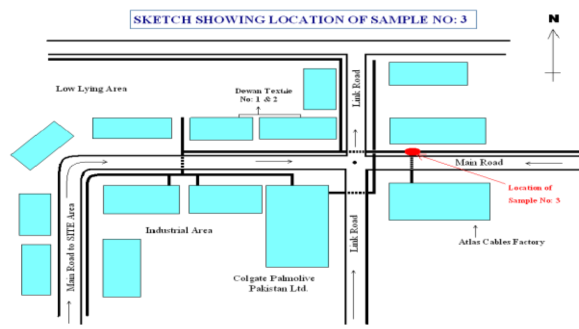

Fig. 4: Location of Sample No: S-3

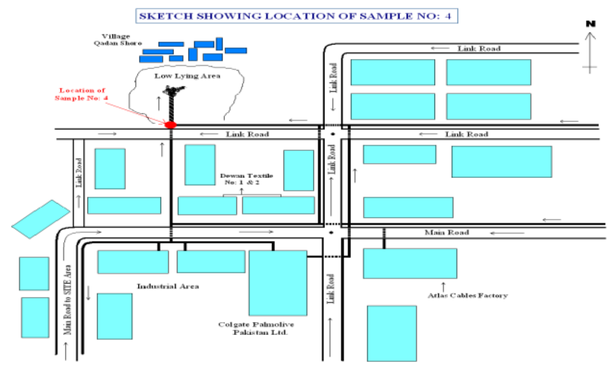

Fig. 5: Location of Sample No: S-4

Location of **Sample No. S-5** (Figure.6) was at the outfall of open drain (earthen) which flows towards the K.B. Feeder canal which is flowing in the east of the SITE area.

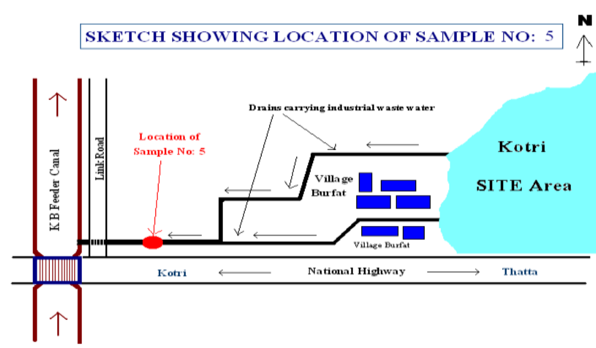

Fig. 6: Location of Sample No: S- 5

RESULTS AND DISCUSSIONS

The results of pH values of all sample sites are shown in Figure 7. It indicated that the sample sites S-2 and S-4 have slightly higher pH values compared with the NEQS standard. This may be because the Location of S-2 sample was receiving the combined wastewater from the detergent and paper and pulp factories at the time of 1st batch of sample collection when these factories were under operation. Whereas the values of remaining samples, are within the permissible limits of NEQS. The lower values of S-2 sample site than the NEQS limit at other times of sample collection were due to the reason that factories were nonfunctional at that time.

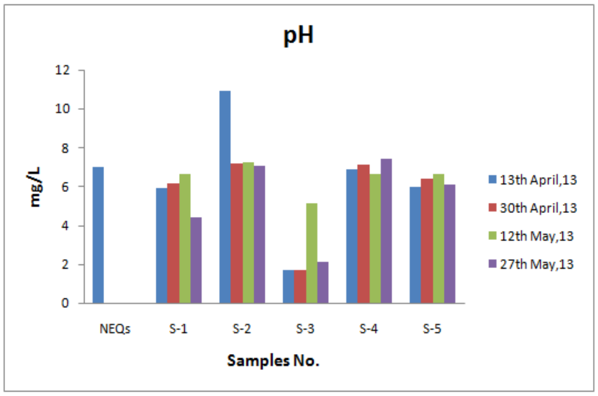

Fig. 7: Comparison of pH Samples NEQS

Organic Substance

Total Suspended Solids (TSS): Wastewater contains a variety of organic solid material, varying from rags to colloidal material. Total solids are obtained by evaporating a sample of wastewater to dryness and measuring the mass of the residue. A filter is used to separate the TSS from the TDS. The values of the samples at all sites except S-3 site have shown extremely higher values than the permissible limits of NEQS (Fig. 8). Whereas, the values of S-3 sample site was slightly higher than the permissible limit indicating presence of less suspended solids. The higher values of TSS were found during the time when all the units were functional and discharging wastewater into the open drains that creates turbulence in settled particles of the stagnant water in suspension resulting increased in particles raising TSS values. The TSS values decreased when the waste water became stable and particles settled down in the depression.

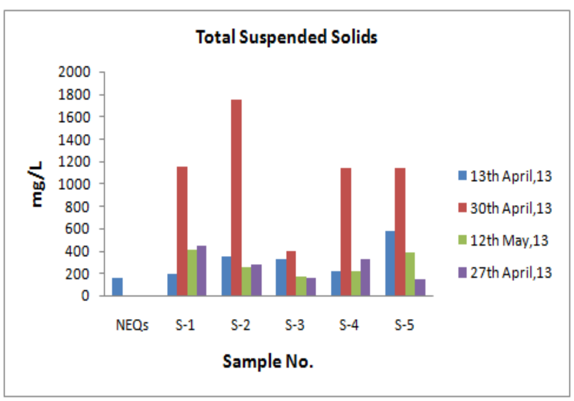

Fig.8: Comparison of TSS Samples with NEQS

Total Dissolved Solid (TDS): All the sample sites except S-3 site indicated TDS values within the permissible limits of NEQS (Fig. 9). The higher TDS values of sample site S-3 was observed after regular cleaning operation of electrical cables factory during the collection of 2nd batch of samples.

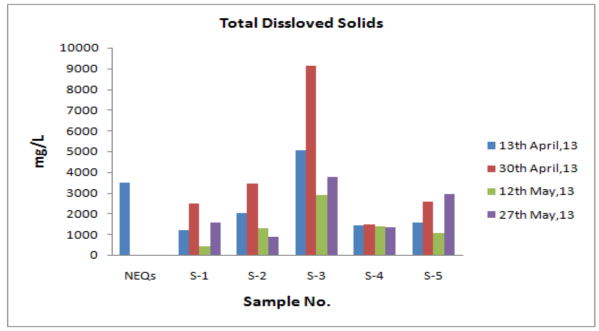

Fig. 9: Comparison of TDS Samples with NEQ

Hardness: It is the capacity of a substance to scratch or to be scratched. The quality attributed to water containing dissolved Calcium and Magnesium salts, the presence of which inhibits the formation of soapsuds. The hardness of all the sample sites S-1, S-2, S-4 and S-5 (Fig. 10) were within the limits of NEQS, whereas of hardness of sample S-3 was higher than the permissible limit. This may be due to regular cleaning operation of industrial unit at that location.

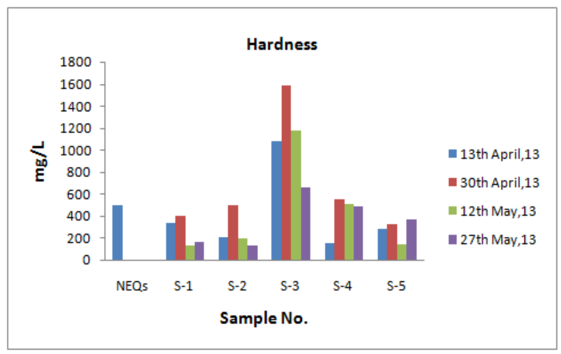

Fig. 10: Comparison of Hardness Samples with NEQS

Chemical Oxygen Demand (COD): The COD is a test used to measure the oxygen equivalent of the organic material in wastewater that can be oxidized chemically using dichromate. All the sample sites except site S-5 (Fig. 11) indicated higher values than the permissible limits in NEQS. The lower value of COD at the location S-5 was due to retention of wastewater in the local depression, flow conditions and aeration.

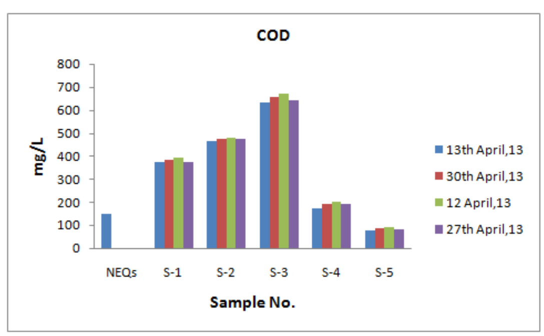

Fig. 11: Comparison of COD Samples with NEQS

Biochemical Oxygen Demand (BOD5): All the sample sites except S-5 site (Fig. 12) indicated higher values than the permissible limits in NEQS. The lower value of S-5 sample site than the NEQS was due to retention of the wastewater in the local depression.

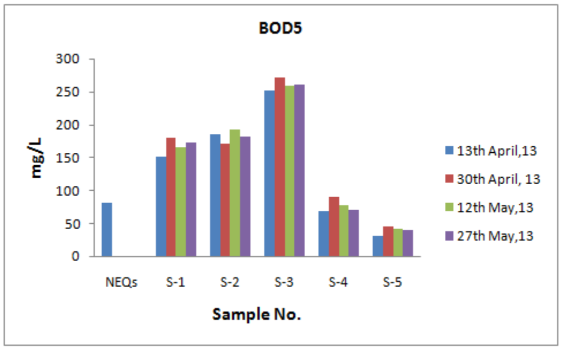

Fig. 12: Comparison of BOD Samples with NEQS

Inorganic Substance

Metals: the Values of copper (Cu), Iron (Fe), Zinc (Zn), Nickel (Ni), Cobalt (Co) and Chromium (Cr) at all sites of sampling indicated lower values than the safe limit as recommended by NEQS. Data revealed that the values of Cu, Fe, Zn, Ni, Co ranged 0 - 0.010 - 059, 0.0118 - 0.98, 0.0114 - 0.057, 0.0144 - 0.028, 0.0131 - 0.37 and 0.0041 - 0.016 respectively. The values of Zinc in all sites of samples were almost negligible, whereas the values of Cobalt were high in the magnitude. The samples detected high values may be due to generation of combined effluent of cluster of industries and the use of raw material containing specific metal combination. Another metal like Cadmium (Cd) in 3 out of 5 sample sites indicated higher value than the NEQS. The values of Cd ranged from 0.010 to 0.016.

Sample site S-4 contained 60 % more Cd than the values recommended in NEQS (Fig. 13). The higher values of Cd may be attributed by generating substance of cadmium from the specific industries like vegetable oil, batteries and cable etc. Work place exposure to Cadmium is particularly hazardous in the presence of Cadmium fumes or air borne Cadmium. Other occupations include the manufacture of paint pigments, Cadmium-Nickle batteries and electroplating. A major source of respiratory Cadmium is cigarettes. Acute toxicity may result nausea, vomiting, abdominal pain, chronic pulmonary diseases. Cadmium is toxic to renal tubular cells, skeletal effects, hyper tension and cardiovascular effect and carcinogenicity.

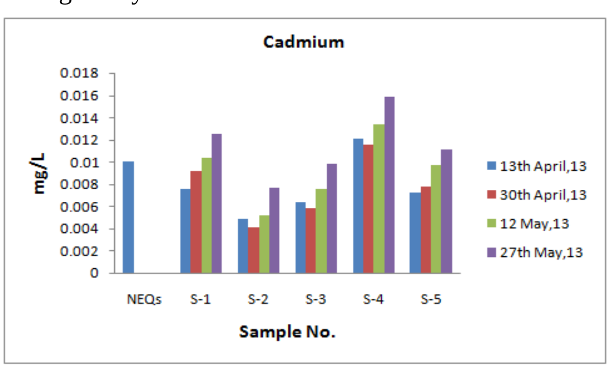

Fig. 13: Comparison of Cadmium Samples with NEQS

Chloride (Cl_2): In study area 2 out of 5 samples at sites S-3 and S-5 indicated higher values of chloride concentration in the industrial effluent than the admissible values in NEQS. Whereas other sample sites indicated just near to threshold values of NEQS (Fig. 14). The presence chloride may cause corrosion of the metal pipes.

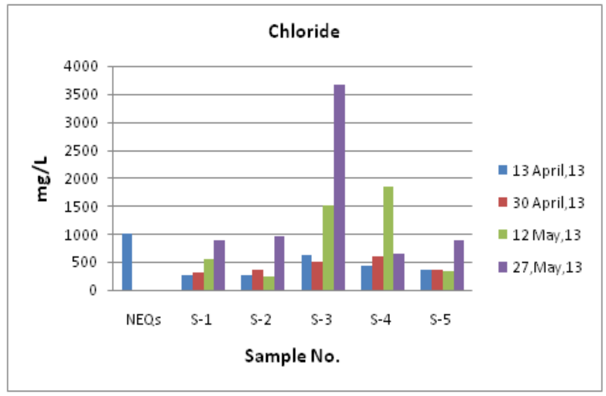

Fig. 14: Comparison of Chloride Samples with NEQS

Ortho phosphate (PO_4): Out of 5 sample sites, only one sample site S-3 indicated higher quantity of phosphate available in the wastewater (Fig. 15). This may be due to generation of water the detergent factory that mixes at the particular location. The maximum value attained at S-3 sample site during last collection of sample was due to function of all factories generating full concentration of phosphate in the effluent.

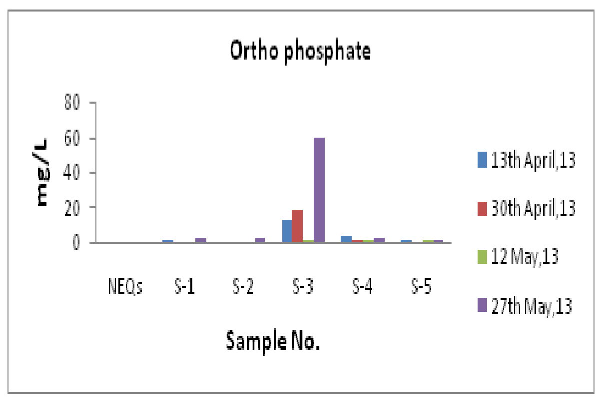

Fig. 15: Comparison of PO_4 Samples with NEQS

Sulphate (SO_4): Figure 16 shows the results of Sulphate analysis of sample sites. The results indicated that one out 5 sample sites S-2 higher values of sulpate concentration in waste water than other sample sites and the value was much higher than the recommended NEQS standard. S-4 sample site was nearly approaching to threshold value of NEQS. The other sample sites were much below the recommended standard. The higher concentration of sulphate in wastewater of S-2 sample site was due to effluent generated from all the factories including the detergent factory at that site.

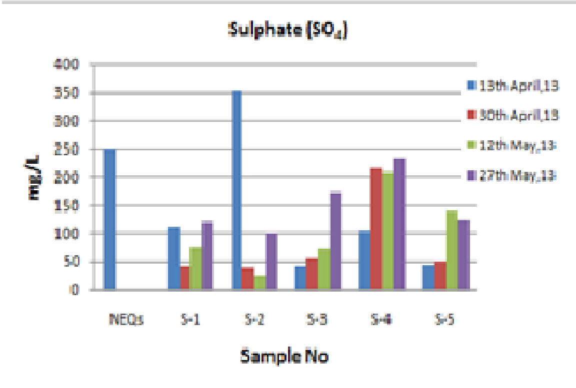

Fig. 16: Comparison of SO_4 Samples with NEQS

Ions (Mg, Na): The results of study indicated that the Sodium (Na) of the waste water was higher than the NEQS threshold value in all 5 sample sites (Fig. 17). This is due to the various categories of factories including Textile, Soap, Paper, pulp and other units, using Sodium for the manufacturing purpose. Whereas the values of the Magnesium (Mg) of all sample sites, except S-1 were below the permissible limit recommended in NEQS.

Potassium (K): Due to the usage of larger quantity of Potassium in the Colgate and Palmolive industrial units, the results indicated that the Potassium at location S-2 (Fig. 18) is higher than the NEQS standard .This was due to concentration of effluent generated by operation of all factories including soap and paper factories at that location.

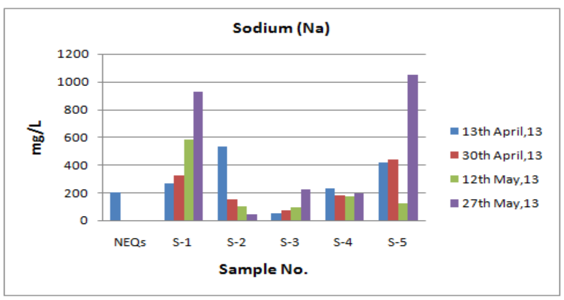

Fig. 17: Comparison of Na Samples with NEQS

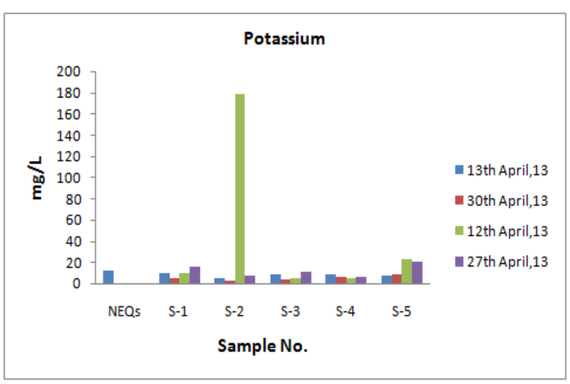

Fig. 18: Comparison of K Samples with NEQS

The results of organic solids such as TSS, TDS, BOD5, COD revealed that 80% of sampling sites had highest BOD5, COD, TSS and TDS than the admissible limit of NEQS. Whereas inorganic solids such as Cr, Cu, Fe, Ni, Zn, Co are potentially toxic, their present with high concentration may likely to affect human health but the concentration of these parameters analysis indicated that their values are below the safe limit of NEQS. In addition high concentration of ions such as chloride and Sodium etc may cause problems to fresh waterways and aquatic life. Further analyses ions have shown that 2 out of 5 sites were contaminated with chloride higher than the admissible limit, whereas the concentration of sodium was found higher than the admissible limit in all sampling sites. The high concentration of these ions will have the detrimental effect on agriculture due to its phototoxic effect. The concentration values of ortho-phosphate and sulphate, hardness and magnesium were lower than the safe limit of NEQS in 4 of the 5 sample sites. The pH of two sites S-2 and S-4 was higher than the recommended in NEQS. The results further show that the drains, which are receiving wastewater generated from different categories of Industrial units discharging in the depressions S-1, S-2 and S-3 near Burfat, Qadan, Shoro and Khoso respectively may deteriorate water quality of canal water, groundwater, livestock, agriculture and degradation of environment and soil in the area. As being the signatory of WTO accord, there is need to follow ISO-14000 standard for protection of environment degradation and to compete the product in international market. This can be achieved by adopting both options of Primary Treatment with Trickling Filters and Oxidation Ponds for wastewater treatment in accomplishing better results of reducing the BOD5 and COD,TSS, TDS, Na, Cl and other physico-chemical load of wastewater generating in the vicinity of Kotri Industrial area.

CONCLUSIONS

The study on the impact of effluent quality generated from different categories of industrial units at five sampling sites of Kotri Industrial State concludes as under:

1. The BOD5, COD, TSS, TDS and Na were found very high in all sample sites compared to permissible limit of National Environment Quality Standards of Pakistan (NEQS), whereas the concentration of ortho-phosphate, sulphate, hardness and Magnesium was below the admissible limit of NEQS in 4 out of 5 sampling sites. Conversely the concentration level of inorganic substance (metals) such as Cd, Cr, Cu, Fe, Ni, Zn was found below the safe limit of NEQS.
2. Untreated wastewater generated by industries is released into fresh waterways causing serious threat to groundwater, agriculture, livestock, people and degradation of environment. The adverse impact of untreated wastewater may be rectified by installing both options of primary treatment with trickling effect and oxidation ponds, before it is too late.

It is suggested that further studies may be conducted on the quality of surface canal water and groundwater in the area to assess the quality of irrigation water as a result of industrial wastewater mix as has been carried out [20].

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