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Study of the pollutants in wastewater from edible oil/ghee industries and their impacts on plant life, Islamabad, Pakistan

Muhammad Zaheer Afzal[1]*, Dr.Muhammad Ikram[1], Shazia Israr[2]
[1]Department of Earth and Environmental Sciences, Bahria University Islamabad, (PAKISTAN)
[2]Department of Environmental Sciences, Federal Urdu University of Arts, Sciences & Technology Islamabad, (PAKISTAN)
E-mail : zaheer.afzal82@gmail.com

ABSTRACT

Present study was conducted for the analysis of pollution load in the wastewater from edible oil and ghee industries of Islamabad. For this purpose randomly fifteen (15) samples from five (5) industrial units in triplicate were collected and various physical and chemical parameters were analyzed. The observed data were compared with the National Environmental Quality Standards (NEQS) of Pakistan and it was observed that majority of the wastewater samples contained pollutants beyond the permissible limits. Due to open disposal of untreated wastewater, the environmental issue of underground/surface water quality around the industrial area has been badly deteriorated over the past several years resulting in the de-oxygenation which could be harmful for aquatic life.

KEYWORDS

B.O.D;
C.O.D;
Edible oil and ghee;
Oil and grease;
Ph.

INTRODUCTION

Water is an absolutely essential component of life and plays a vital role in our daily routine life and its pollution is one of the major problems of today. It is considered to be the universal solvent because of its use in each and every industry and is thrown into the hydrosphere in the form industrial effluents which consists of both suspension and solution.

Wastewater from industrial units in Pakistan is normally not treated even the capital city, Islamabad: the well planned city of Pakistan but lacks proper water pretreatment system and the industrial effluent is fed to the Nala Lye which then finds its way to the River Indus and the agricultural fields via River Sawan. The disposed of industrial effluents have enhanced the chances of many diseases also. Industrial wastewater contains both organic and inorganic pollutants in the form of oxygen demanding wastes, disease causing wastes, mineral acids and finely divided metals etc. Although some of them in trace amount are useful in biological processes but may become toxic if present in high concentration.

Generation of wastewater in an edible oil industry is of two types i.e. process wastewater and auxiliary wastewater. Both of these two vary in concentration and pollution load. Auxiliary wastewater is of high temperature with traces of volatile organic compounds (VOCs) whereas the other one is rich in oil & grease, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total dissolved solids (TDS), total

suspended solids (TSS), sulfates, chloride, phosphate and nickel etc.

The aqueous weeds and algal growth in water bodies is stimulated by the oil in wastewater coming from edible oil and ghee industries resulting in the degradation of water bodies for agricultural use along with the loss of Dissolved Oxygen (DO) by eutrophication. DO in the range of 4-6 mg/L is very important for aqueous organisms but due to bacterial activity it suffers depletion. Sediments and suspended solids arise due to soil erosion and are of major concern as they inhibit the photosynthesis by blocking the sunlight.

Industrial Estate Islamabad

Industrial Estate Islamabad (I-9 & I-10 sectors) established in 1963 contains more than 200 industries and managed by the Capital Development Authority (CDA). It is spread over 625 acres of land on the border of cities of Rawalpindi and Islamabad having a good network of roads within the estate. Number of industrial units have installed their own tube wells due to inadequate supply of water from CDA. The waste water drains originating from the industrial units are connected to natural drains within industrial estate. The natural drains eventually lead to a single main water stream in the area, known as Nala Lye and then make its path to Sawan River and Indus River as mentioned earlier.

OBJECTIVES OF THE STUDY

- To study the water pollution caused by edible oil/ ghee industries in Islamabad.
- To study the possible impacts of different pollutants released in the wastewater from edible oil/ghee industries on plants[13] life.

EXPERIMENTAL

Five industries affecting the surrounding area were chosen for the study and samples were collected in triplicate within a distance of 30 meters. Sample bottles and glassware were pre-washed with 1:1 HNO3 followed by rinsing with distilled water and drying at 80C. All glassware used during the investigation was made of high quality, acid resistant borosilicate glass of pyrex. Analytical grade chemicals were used throughout and all analytical parameters were measured by using standard methods involving the following instruments.

- SM 802 pH/EC/TDS meter for pH, electrical conductivity, total dissolved solids
- Spectrophotometer (UV 4000, Germany) for sulfates and chemical oxygen demand
- BOD analyzer (JK-BOD-CY) for biochemical oxygen demand
- Atomic Absorption Spectrophotometer (AA6300, Japan) for nickel
- Classic techniques such as filtration (for total suspended solids), solvent extraction (for oil& grease) and titrimetric (for total hardness, calcium, magnesium and chlorides).

RESULTS AND DISCUSSION

Unregulated and indiscriminate discharge of industrial waste is the greatest threat by industrial pollution and is degrading the environment of the Islamabad Industrial Estate through wastewater, solid wastes and fumes.

As far as the pH of water is concerned, it plays a vital role in existence of aquatic life and major deviation from its neutral value could cause in the alteration of the natural biological activities. Also, biodegradation of organic pollutants is not facilitated by acidic or basic water. Measured values of pH are between 7.70 and 8.30 which are well within the permissible limit of 6 – 10 set in National Environmental Quality Standards (NEQS) of Pakistan. The temperature of all effluent samples falls within the permissible limit of 40°C as indicated by NEQS and it ranges from 28.5°C – 31.3°C.

Dissolution of ions from dissolved solids gives rise to the value of Electrical Conductivity (EC) which increases the ability of water to conduct more electric current The EC values measured in the project area range from 1266.0 to 2136.5 µS/cm.

Hydrogenation of oil is done to improve its stability against oxidation by decreasing the unsaturation. The process is also called the hardening of oil and is done by passing hydrogen gas through oil in the presence of nickel as catalyst[11]. Nickel being the heavy metal is of great concern because some of it is thrown into the effluent while its major portion as solid waste. In water, it can exist either in dissolved form or attached to

suspended material[5]. According NEQS, the permissible limit of Ni is 1.0 mg/L but the results show the Ni concentration up to 13.67 mg/L due to unregulated release of industrial effluents, the observed concentration of Nickel was very high in all samples.

By definition oil & grease is a material recovered in the solvent as a soluble substance. It also includes other materials present in an acidified sample extracted by the solvent. Presence of fatty matter may also possible due to lack of specially modified industrial products. All samples have oil & grease values more than the allowable limit as per according to NEQS which is 10 mg/L and results obtained are 36 to 76 mg/L.Where AC, PU, FA, SI, SE are the sample codes of the following industries respectively. ACP edible oil and ghee industries, Punjab edible oil and ghee industries, Fazal edible oil and ghee industries, Sitella oil and ghee mills and Sihala edible oil and ghee mills.

Filterable and non-filterable residues are also termed as Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) respectively. Dissolved solids are responsible for imparting the color, taste and odor to the water and situation may become dangerous if the two or more dissolved solids combine to form another compound more dangerous than the original. According to NEQS, permissible limit for TDS is 3500 mg/L and for TSS is 150 mg/L whereas the measured values of range from 567 to 1002 mg/L and 137 to 242 mg/L respectively.

Measured values of BOD and COD are 520 to 1139 mg/L and 1012 to 2105 mg/L which are higher than the permissible limit of NEQS i.e. 80 mg/L and 150 mg/L respectively. Punjab edible oil and ghee industry (PU) has the highest BOD and COD values. The COD of the effluents have higher COD values than the NEQS (150mg/L). Therefore these effluents need further elimination of COD through proper treatment methods before irrigation.Chloride ions are one of the major inorganic anions in water and wastewater. Results obtained were from 218 to 342 mg/L which shows no deviation from permissible limits of NEQS i.e. 1000 mg/L. It is difficult to reduce its

TABLE 1 : Results of temperature, pH, electrical conductivity, nickel and oil & grease of wastewater samples collected from 5 ghee industries of Islamabad

Site	Temperature (°C)	pH	Electrical Conductivity (µS/cm)	Nickel (mg/L)	Oil & Grease (mg/L)
AC	29.73±0.06 (29.7–29.8)	8.27±0.06 (8.2–8.3)	1378.3±1.15 (1377.0–1379)	11.3±0.61 (10.9–12.0)	51.3±0.58 (51–52)
PU	30.1±0.1 (30.0–30.2)	8.01±0.06 (8.0–8.1)	1268.7±1.15 (1268.0–1270)	8.17±0.25 (7.9–8.4)	36.7±0.58 (36–37)
FA	28.57±0.06 (28.5–28.6)	8.01±0.06 (8.0–8.1)	2135.3±1.15 (2134.0–2136)	9.97±0.06 (9.9–10.0)	72.3±0.58 (72–73)
SI	31.07±0.06 (31.0–31.1)	8.27±0.06 (8.2–8.3)	1266.7±0.58 (1266.0–1267)	6.28±0.006 (6.28–6.29)	75.3±0.58 (75–76)
SE	28.83±0.06 (28.8–28.9)	7.7±0.1 (7.7–7.9)	1297.7±0.58 (1297.0–1298)	13.37±0.12 (13.3–13.5)	60±1 (59–61)

Note : The mean concentrations for each site are given along with their standard deviations and ranges in parenthesis

TABLE 2 : Results of total dissolved solids, total suspended solids, biochemical oxygen demand and chemical oxygen demand of wastewater samples collected

Site	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	Biochemical Oxygen Demand (mg/L)	Chemical Oxygen Demand (mg/L)
AC	670±1 (669–671)	241.3±0.58 (241–242)	601.7±1.53 (600–603)	1013.7±1.53 (1012–1015)
PU	567.7±1.15 (567–569)	145±1.00 (144–146)	1137.3±1.53 (1136–1139)	2103.3±1.53 (2102–2105)
FA	1000.3±0.58 (1000–1001)	380.7±1.15 (380–382)	615.3±0.58 (615–616)	1038.3±1.53 (1037–1040)
SI	620.7±1.15 (620–622)	136.7±0.58 (136–137)	521±1 (520–522)	1095±1 (1094–1096)
SE	604.7±1.15 (604–606)	139.3±1.15 (138–140)	870±2 (868–872)	1513±2 (1511–1515)

Note : The mean concentrations for each site are given along with their standard deviations and ranges in parenthesis

TABLE 3 : Results of total hardness, calcium, magnesium, chloride and sulfate content of waste water samples collected from 5 ghee industries of Islamabad

Site	Total Hardness (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
AC	200.3±0.58 (200–201)	107.3±0.58 (107–108)	91.7±1.15 (91.0–93.0)	241.3±0.58 (241–242)	167.3±0.58 (167–168)
PU	180.7±1.15 (180–182)	110.3±0.58 (110–111)	70.3±0.58 (70.0–71.0)	341.3±0.58 (341–342)	157.3±0.58 (157–158)
FA	132.7±0.58 (132–133)	90.3±0.58 (90–91)	42.3±0.58 (42.0–43.0)	218.7±0.58 (218–219)	109.3±0.58 (109–110)
SI	167.3±0.58 (167–168)	92.3±0.58 (92–93)	75±1 (74.0–76.0)	235.7±0.58 (235–236)	158.7±0.58 (158–159)
SE	198.7±0.58 (198–199)	114.3±0.58 (114–115)	84.3±0.58 (84.0–85.0)	279.3±0.58 (279–280)	110.7±0.58 (110–111)

Note : The mean concentrations for each site are given along with their standard deviations and ranges in parenthesis

concentration through conventional treatment which makes it unfit for irrigation.

Concentration of sulfate in waters varies. Its high value is common in the effluents of those industries which employ sulfuric acid. Results obtained range from 109 to 168 mg/L which are well within limits of NEQS i.e. 600 mg/L. Under anaerobic conditions, sulfate is reduced to sulfide which on combining with hydrogen forms hydrogen sulfide (H_2S) which then oxidizes to sulfuric acid which causes corrosion of the sewer pipes. Hydrogen sulfide gas can also be fatal for humans on direct exposure.

The total amount of polyvalent ions especially magnesium and calcium in the water is termed as its hardness. This term arises from the fact that calcium and magnesium make the water hard by combining with soap molecules[8]. The hardness ions have tendency to combine with carbonates, bicarbonates, chlorides and sulfates thus are responsible for the pleasantness of water. Total hardness measured was between 132 and 201 mg/L and that of calcium and magnesium were 90 to 115 mg/L and 41.7 to 93.7 mg/L respectively.

IMPACTS OF WASTEWATER POLLUTION ON PLANTS

The wastewater has major damaging impacts on plants and the surrounding population. Wastewater from edible oil and ghee industries contains by-products from processes in the form of oil, nickel, COD etc and is discharged without any treatment and restriction into the watercourses and rivers. This polluted water is then eventually used for irrigation purpose by farmers to save their expenses and its harmful effects last for several years[3]. Also it makes the vegetation surface a plate form for pollutants and parasites interaction. It also affects surface water bodies as well as groundwater bodies at shallow depth[12].

It was observed that the plants grown in the areas which are irrigated with industrial effluents have reduced amount of chlorophyll and carotene than that of grown in the non-polluted areas[7]. Different medicinal plants like Lepidium Sativum, Silybum marianum and Amm visnaga growing in highly polluted and industrial areas were also found with elevated concentrations of cadmium, nickel, lead, iron and copper[6].

A lot of nickel discharged into the environment has cumulative effects which can find its way to sediments or soil where it strongly attached by the particles containing iron or manganese and if it is provided with acidic conditions makes its way to ground water. High concentration of nickel in soil also hinders the growth of woody plants. It may also enter into the food chain[4].

Presence of oil and grease in wastewater disturbs the process of photosynthesis by forming a thin film on the surface of water which hinders the transmission of sunlight through water necessary for photosynthesis leading to destruction and creating an imbalance in the aquatic ecosystem[1]. Efficiency of wastewater treatment is also decreased by the interference of certain constituents of the oil & grease in excessive amounts with aerobic and anaerobic biological processes[2]. Also its high amount in the wastewater may reduce the absorption of oxygen by the receiving water bodies, hence resulting in the depletion of dissolved oxygen causing danger to aquatic life.

TSS consists of settle able and non-settle able matters which cause turbidity of the water thus reducing the percentage of light. As a result, photosynthesis

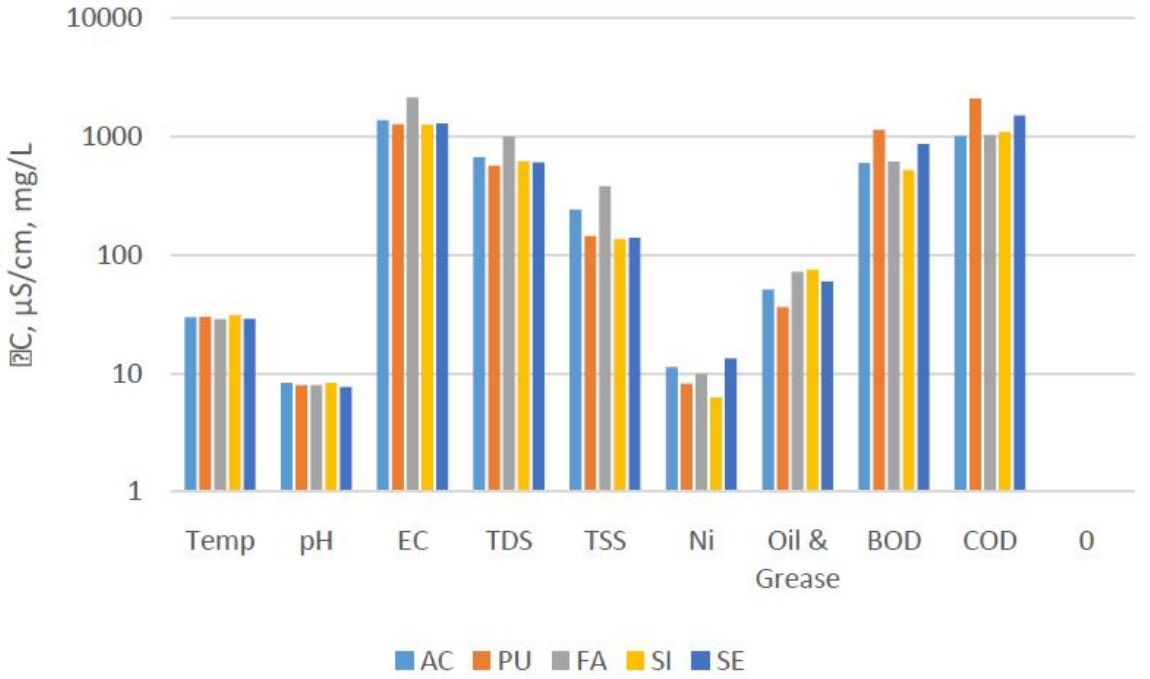

Figure 1 : Graphical representation of temperature, pH, EC, TDS, TSS, Ni, Oil & Grease, BOD and COD

Figure 2 : Graphical representation of total hardness, Calcium, Magnesium, Chloride and Sulfate

process is affected causing destruction of plant life which in turn, disturbs the aquatic life due to its dependence on these plants. When these suspended solids settle, they destroy fish spawning grounds and organism used as basic food by fish and can also plug the fish gills resulting into their mortality.

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are the most important parameters of the wastewater quality which indicate that how much oxygen will be depleted from the water if all the organic and inorganic matter undergoes oxidation or biodegradation by bacterial activity respectively. Higher the values of these, more the oxygen will deplete resulting in the rise of pollution levels of the receiving water body.

Depletion of oxygen generates anaerobic conditions which cause detrimental impacts on the aquatic life

including the alteration of stream ecology by the extinction of certain species except only few which adapt to these conditions. It also causes the reduction in population of normal oxygen-consuming bacteria and makes conditions suitable for those bacteria which produce hydrogen sulfide gas (H_2S) because they prefer to live on sulfur rather than oxygen[9]. Also at low oxygen level, microorganisms in the sewage reduce the nitrates, sulfates and ferric into nitrite, sulfides and ferrous respectively creating a great nuisance for the environment[10]. Hence these effluents are unfit for irrigation because both of the soil fertility and ground water can be affected.

CONCLUSIONS

Edible oil/ghee industries in Islamabad are considered to be the major source of environmental pollution due to negligence of the concerned authorities which has resulted in the ever-increasing stress of pollutants both on soil and groundwater.

Demand for industrialization is need of the time but our environment is already much absorbed with industrial wastes which is causing the degradation of living standard of man as well as flora and fauna and natural ecosystem. Water pollution due to slower rate of self-purification and regeneration than that of air is considered to be more complex.

The concentrations of BOD, COD, oil & grease and nickel are much higher than the permissible limits of NEQS. Although temperature of all the samples is within the permissible limit i.e. 40°C but it may still accelerate the lowering of dissolved oxygen levels which is fatal for fish.

The pH, conductivity, chlorides and sulfates of the samples are within the range. The total suspended solids can be decreased by settling the effluent in ponds. Such water with high concentrations should be avoided for agricultural and irrigation purposes and the whole system should be examined and a workable model be prepared for the treatment of effluents.

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