

Analysis of Physico-Chemical Parameter, Heavy Metal Content and microbial load in Battery Industry Effluent

H. Vajihabanu¹, M. Kannahi^{2*} and D. Angelin Mary²

¹M.I.E.T. Arts and Science College, Trichy, Tamil Nadu, India

²S.T.E.T Women's College, Mannargudi, Tamil Nadu, India

*Corresponding Author E-mail: kannahiamf@gmail.com

ABSTRACT

This research is an attempt to analyze the water quality of the both treated and untreated effluent from the battery production industry. In this investigation, physico-chemical parameters such as pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Nitrate (N) and Phosphate (P) and heavy metals such as Iron (Fe), Copper (Cu), Zinc (Zn) and Manganese (Mn) had been analyzed from the effluent collected from the battery industry of Pudukottai region. The physico-chemical parameter and heavy metal concentration of treated effluent shows lesser concentration when compared with untreated effluent.

Key words: Battery industry effluents, Physico-chemical parameter, Heavy metals

INTRODUCTION

Much of the current concern with regards to environmental quality is focused on water because of its importance in maintaining the human health and health of the ecosystem¹. The addition of various nutrients and pollutants through the sewage, industrial effluent into water bodies bring about a serious change in physico-chemical characteristic of water. Pollution due to chemicals, including heavy metals, is a problem that may have negative consequences on the biosphere. The most abundant pollutant in the waste water and in sewage is heavy metals².

Since every treatment system is in itself a separate ecosystem, one has to custom – design each application for a waste treatment system after the proper assessment of the entire system. The indicators like pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Nitrate (N) and Phosphate (P) need to be treatment of waste water, to observe the efficiency of the selected process. BOD is defined as the amount of oxygen required by bacteria while stabilizing the organics in wastewater under aerobic conditions at a particular time and temperature. Sewage with high BOD can deplete oxygen in receiving waters, causing fish kills and ecosystem changes. COD is another most commonly measurable constituent of wastewater. This is a measure of the total quantity of oxygen required for oxidation of organics into carbon dioxide and water by use of chemicals.

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Total solids (TS) comprise the combination of Total Suspended Solids (TSS) and Total Dissolved Solids (TDS). These mainly represent suspended solids and dissolved solids that are organic and inorganic in nature. Excess of nitrate and phosphate into water causes lethal effect known as eutrophication have a massive impact on ecosystem³.

Heavy metals are widespread pollutants of great concern as they are non degradable and thus persistent. These metals are used in various industries from which effluents are consequently discharged into the environment. Common sources of heavy metal pollution include discharge from industries such as electroplating, plastics manufacturing, fertilizer producing plants and wastes left after mining and metallurgical processes⁴.

EXPERIMENTAL SECTION

Sampling Area

The treated and untreated raw effluent sample was collected from a Battery Production Industry at Aavor, Pudhukottai (Dt), Tamil Nadu.

Sample Collection

In this study, water samples have been collected in polythene bottles with necessary precaution at point at which effluents discharge into drains for laboratory analysis.

Physico-chemical Parameter Analysis

Determination of parameters like Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Nitrate (N) and Phosphate (P), Bi-carbonate, Chloride, Calcium and Magnesium were carried out using standard methods⁵. pH determination was carried out through pH-meter.

Preparation of raw effluent samples for AAS

5ml from each effluent was placed in different crucibles and heated in a maple furnace at 700°C for 3 hours to vaporize all other constituents and leave the heavy metals as a pure ash. The ash was cooled to room temperature before being dissolved in a 5 ml solution of nitric acid (1:6) to compound with the heavy metals, if present. The solution was subsequently heated and evaporated to half its volume using a hot plate. The resulting solution was then poured into a volumetric flask, or Erlenmeyer flask, and topped up to 25 ml with distilled water.

Atomic Absorption Spectrophotometer analysis⁶

Analysis of the heavy metal contents in the battery effluent sample has done with the use of Atomic Absorption Spectrophotometer (AAS) following the 7000B method of EPA (Environmental Protection Agency) for flame absorption spectrophotometry. The AAS not only detects the presence of heavy metals, but if present, it is also designed to provide the concentration in parts per million (ppm). Three trials were run on each battery effluent in every replicate of the heavy metal and the averages of the concentrations were then taken and compared to provisional tolerable weekly intake as stated by the Food and Agricultural Organization/World Health Organization Joint Expert Committee on Food Additives (JECFA). Atomic Absorption Spectrophotometer relies heavily on the Beer-Lambert Law. The electrons of the atoms in the atomizer can be promoted to higher orbital for a short amount of time by absorbing a set quantity of energy i.e. light of a given wavelength. This amount of energy or wavelength is specific to a particular electron transition in a particular element, and in general, each wavelength corresponds to only one element. This gives the technique its elemental selectivity. As the quantity of energy put into the flame is known, and the quantity remaining at the other side (at the detector) can be measured, it is possible, for Beer-Lambert Law to calculate how many of these transitions took place, and those get a signal that is proportional to the concentration of the element being measured.

Microbial populations

Microbial populations such as bacteria, was carried out for different water samples following standard dilution plate technique⁷. In this method, 1 mL water sample was taken and volume was made up 100 mL with sterile water which was further serially diluted to get 10⁻⁴ dilution. From these diluted samples, 1 mL water sample was dispensed over each of three replicates and then media for growth of different microorganisms were added nutrient agar used for isolation of bacteria. The Petri plates were incubated at

35 °C for 48 h for bacteria. The microbial populations were enumerated as colony forming units (CFU) from a serial dilution of soil suspensions. The bacterial colonies were counted in the three replica plates and the average values were calculated. The populations of bacteria were considered from the number of bacteria multiplied by the dilution factor for each sample.

Maximum Tolerate Concentrations⁷

The maximum tolerable concentration of the metals were analysed at several dilutions of the metal salt was prepared based on preliminary screening (5µg and 100µg). To each set, a bacterial culture was inoculated and plates were incubated at 37°C for 24 hours. After this incubation period, the plates were observed for growth by streaks on Nutrient Agar plates. Strains that could not grow on 5µg were termed as sensitive to the metal, while that which grow in 5µg were further tested for higher concentration (100µg).

RESULTS AND DISCUSSION

Analysis of Physico-chemical Parameter

The pH value of untreated effluent sample was observed to be 5.4. i.e. highly acidic. The Electric conductivity is 0.1, dissolved oxygen level effluent is 10.2 mg/l, BOD level is 32.4 mg/l, COD level is 37 mg/l, TS level is 94 mg/l, TDS level is 60 mg/l, TSS level is 34 mg/l, Nitrate content is 6.4 mg/l, Chloride content is 2.0 mg/l, Bi-carbonate is 0.7 mg/l, Calcium content is 1.4 mg/l, Magnesium is 5.1 mg/l and the Phosphate content 3.2 mg/l were estimated (Table-1).

The untreated effluent contains heavy metals such as Iron (0.01ppm), Copper (0.0061ppm), Zinc (0.038ppm), Manganese (0.036ppm), Lead (0.0323ppm), Chromium (0.0037ppm) (Table-2).

The pH value of treated effluent sample was observed to be 7.32. i.e. slightly alkaline. The Electric conductivity is 0.31, dissolved oxygen level effluent is 14.4 mg/l, BOD level is 34.2 mg/l, COD level is 39.2 mg/l, TS level is 88.4 mg/l, TDS level is 58 mg/l, TSS level is 30.4 mg/l, Nitrate content is 5.9 mg/l, Chloride content is 2.4 mg/l, Bi-carbonate is 1.2 mg/l, Calcium content is 2.6 mg/l, Magnesium is 0.2 mg/l and the Phosphate content 2.7 mg/l were estimated (Table-1).

The treated effluent contains heavy metals such as Iron (0.02ppm), Copper (0.0029ppm), Zinc (0.006ppm), Manganese (0.031ppm), Lead (0.0222ppm), Chromium (-0.0014ppm) (Table-2).

Microbial population

The bacterial species were isolated from heavy metal content in battery effluent by serial dilution and plating technique. The bacterial colonies were identified by using morphological and biochemical studies (Table-3).

Maximum tolerable concentration of heavy metal resistant microorganism

In the present study, the maximum tolerable concentrations of heavy metals were analysed. The identified *E.coli* was grown at 5µg and 100µg of Copper, Zinc, Manganese and Iron. Hence, this organism was considered as heavy metal resistant bacteria (Table-4).

Bacillus subtilis was grown at 5µg and 100µg of Copper and Manganese, hence it is set to be Copper and Manganese resistant organism. It showed sensitivity to Zinc and Iron at minimum and maximum concentration (Table-4).

Staphylococcus aureus was grown only at low and higher concentration of Iron (5µg and 100µg). This organism showed sensitivity to Copper, Zinc and Manganese in both concentration (Table-4).

Table-1: Physico-Chemical Parameter for Untreated and Treated Effluent

S.No	Parameters	Untreated effluent mg/l	Treated effluent mg/l
1	pH	5.4	7.32
2	Electric Conductivity	0.1	0.13
3	Dissolved Oxygen	10.2	14.4
4	Biological Oxygen Demand (BOD)	32.4	34.2
5	Chemical Oxygen Demand (COD)	37	39.2
6	Total Solids (TS)	94	88.4
7	Total Dissolved Solids (TDS)	60	58

8	Total Suspended Solids (TSS)	34	30.4
9	Nitrate	6.4	5.9
10	Phosphate	3.2	2.7
11	Chloride	2.0	2.4
12	Bi-Carbonate	0.7	1.2
13	Calcium	1.4	2.6
14	Magnesium	5.1	0.2

Table-2: Heavy Metal Analysis Value for Untreated and Treated effluent

S.No	Heavy Metal	Untreated effluent (ppm)	Treated effluent (ppm)
1	Iron (Fe)	0.01	0.02
2	Copper (Cu)	0.0061	0.0029
3	Zinc (Zn)	0.038	0.006
4	Manganese (Mn)	0.036	0.031
5	Lead (Pb)	0.0323	0.0222
6	Chromium (Cr)	0.0037	-0.0014

Table-3: Isolation and identification of Bacterial isolates

S.No		Morphological and Biochemical characterization	Isolate 1	Isolate 2	Isolate 3
1	Cultural characteristics	Grams staining	-	+	+
2		Motility	Motile	Motile	Non motile
3	Morphological characteristics	Shape	Rod	Rod	Cocci
4	Biochemical characteristics	Indole	+	-	-
5		Methyl Red	+	+	+
6		Voges proskauer test	-	+	+
7		Citrate utilization test	-	-	-
8		Catalase	+	+	+
9		Triple Sugar Iron test	A/A	A/A	A/A

Table-3: Isolation and identification of Bacterial isolates

S.No	Organism	Heavy Metal			
		Fe	Cu	Zn	Mn
1	<i>E.coli</i>	R	R	R	R
2	<i>B.subtilis</i>	S	R	S	R
3	<i>S.aureus</i>	R	S	S	S

R-Resistant; S-Sensitive

The waste water treatment method is needed to determine the amount of Oxygen demanding wastes in water. The amount of oxygen consumed by microorganisms in decomposing organic waste is proportional to the amount of waste water present. BOD indicates the level of organic matter pollution, the greater value, the greater problem of decomposition water⁸. Analysis of all the generated data of untreated and treated waste water samples observed that pH, BOD, COD, TS TDS, DO, TSS, Nitrate and Phosphate, EC, Chloride, Bi-carbonate, Magnesium, Calcium contents of treated effluent were reduced to tolerable environmental standard. Based on result obtained from liquid treatment it will be interpreted as one of the easy method which can be applied locally to convert the waste into by product which can help to reduce the environmental pollution⁷.

The heavy metal concentration of treated effluent showed lesser concentration when compared with untreated effluent. Our environment has become highly contaminated with mercury as a result of the burning of fossil fuels, particularly coal, for energy. Mercury normally occurs in the earth's crust, but is released either by burning coal, or through incineration of mercury-containing equipment such as thermometers, blood pressure cuffs, electrical switches, thermostats and computer chips. Coal-burning and medical waste incineration are the two biggest sources of mercury contamination in our environment^{8,9}.

Samples from the ground water, CW-5 (tube well) contained the highest number of microbial colonies (142.66 bacteria, 6.66 fungi) except actinomycetes (0). Water samples from Damsala Nala (CW-3) and dug well (CW-4) contained actinomycetes populations 6.0 and 3.0, respectively. It is apparent from the present finding that the number of heterotrophic bacteria in the water was affected by the introduced metal contaminants^{10,11}.

Our study reports similar to Fagade¹² described the isolation of two *Pseudomonas* strains from a battery manufactured effluent. Kriss¹³, reported the isolate *Pseudomonas*, *E.coli* and *Bacillus* strain from kitchen waste.

The concentration of Copper in remaining samples ranged from 0.05 to 1.00mg/l and was above the maximum recommended limit (0.05mg/l) for irrigation purposes. Fe concentration varied from 0.1 to 0.4 mg/l for irrigation except sample Nos.E5 and E6. Manganese was not traceable in sample No:E9 in any of three seasons. Mn ranged between 0.1 and 0.4 mg/l and was not within the recommended limit (0.1 mg/l) for almost all of the samples for land application. Zn varied 0.68 to 60.8 mg/l and was below the critical prescribed limit of 0.5 mg/l for almost all samples, except in samples, except in sample Nos.E3, E4 and E11. For sample Nos.E3 and E4, the concentration of Zn was very far the recommended limit for irrigation purposes¹⁴.

CONCLUSION

Bioremediation is the microbial clean up approach. It is very efficient and eco- friendly techniques to remove the inorganic pollutants from the contaminated site. Safe disposal of domestic wastes and industrial effluents should be practiced and where possible recycled to avoid these metals and other contaminants from going into the environment. This result will therefore help the government, individuals and communities to take necessary measure in controlling heavy metal pollution and to minimize exposure of people living around construction sites.

It is concluded that industrial effluents has the tendency towards toxicity; despite they are within the ranges. Necessary measures especially biodegradation and bioremediation strategies are needed to be adopted for the treatment of effluents before discharges.

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