

Original Research Article

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Microbiological and Physicochemical Analysis of Effluent Discharge of Metal Processing Industries

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ABSTRACT

Keywords

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In this study the physicochemical and microbiological analysis was carried out from effluent discharge of metal processing industries. The results of the physicochemical analysis were obtained in the following range; pH (8.8-10.2), BOD (456.56-1931.48 mg/ L), COD (585.42-1967.51 mg/ L), TDS (23.34- 894.56 mg/L), TSS (63.67-243.45 mg /L), DO (7.3 – 13.5), Oil & grease (7.6 – 21.6 mg/l) and Total coliform count was >100. The microbiological analysis total of 6 industrial effluents samples was collected from various industries, and a total of 42 isolates were obtained among these isolates *Achromobacter* sp. (8), predominantly obtained followed by *Bacillus* sp. (5), *Shigella* sp. (7), *Salmonella* sp. (7), *Pseudomonas* sp. (5), *Corynebacterium* sp. (3), *Staphylococcus* sp. (3), *Proteus* sp. (2), *Exigobacterium* sp. (1) and *Microbacterium* (1). The study can be further extended to investigate the utility of the bacterial isolates recovered in the present study in the bioremediation of metal processing industrial effluents.

Introduction

Metallic pollution is a global concern; the levels of metals in all environments including air, water, and soil are increasing in toxic levels. Metals are introduced into the environment from various sources such as during mining and refining of metallic ores. Agricultural drainage carries dangerous pesticides and fertilizer residues. The rapid expansions of industry and increased domestic activities in the past century have caused a concomitant increase in the quantities of metals that are being released to the environment by industrial waste, which

include recalcitrant xenobiotics, carcinogenic compounds, cyanides, heavy metals, and radionuclide. The natural recycling of some metals that generally occurs in biogeochemical cycles has been disrupted, as a result of the large quantities of metals and pollutants that are currently entering the environment from various sources (Modi, 1996; Pazirandeh *et al.*, 1998; Roane and Pepper, 2000; Vieira and Volesky, 2000).

Effluents from textile, leather, tannery, electroplating, galvanizing, pigment and dyes, metallurgical and paint industries, and other metal processing and refining operations at

small and large-scale sectors contain considerable amounts of toxic metal ions (Ahluwalia *et al.*, 2007). The toxic metals and their ions are not only potential human health hazards but also to other life forms. Toxic metal ions cause physical discomfort and sometimes life-threatening illness including irreversible damage to vital body systems (Malik, 2004).

In steel and Automobile industries metalworking fluids (MWF) are used to optimize the process of machining operations such as turning, grinding, drilling, boring, and milling. They flush away chips and metal fines from tools and work pieces, as well as acting as coolants and lubricants. (Muszynski and Lebkowska, 2005); Oily emulsions are common waste products of petrochemical metal and food processing industries (Coca *et al.*, 2011, Abdel-Raouf 2012); A wide variety of microorganisms including bacteria, fungi, yeast, and algae interact with metals. The structural and functional complexity of microbes helps them to interact with heavy metals in several ways. The interactions of microorganisms with heavy metals can be broadly classified as metabolism dependent (active) and metabolism independent (passive). They can also be classified on the basis of the site of metal interaction viz. extracellular, exocellular, and intracellular (Veglio and Beolchini, 1997).

Microbe related technologies may provide an alternative or addition to the conventional method of metal removal or metal recovery (Chellaiah *et al.*, 2009). Therefore, there is an urgent need for the treatment of the metal processing industry waste. Waste management strategies adopted in India have failed to keep pace with industrial growth and urbanization. So, we have proposed to undertake the studies with the help of microorganisms. Microbiological techniques are efficient and also not very costly. There

are some reports about the growth of microorganisms in wastewater which contain heavy metal, oil, and grease. So, it is very easy to deal with this waste with microorganisms and the use of microbiological techniques.

Materials and Methods

Collection of Effluent Samples

Collected rhizosphere soil samples were used for the physicochemical analysis of soil samples from different locations of the Marathwada region collected in the period 2018-2019 from different sites of the Marathwada region. Samples were collected in a plastic bucket and then thoroughly mixed on a piece of clean cloth and the lumps were broken using a wooden pestle and mortar and were air-dried (Tandon. 1993). After collection, a portion of each sample was immediately transferred to the laboratory and stored at 4 °C for microbial analysis.

Assessment of the Physicochemical Characteristics of the Effluents

Physicochemical parameters of biochemical oxygen demand (BOD), total dissolved solids (TDS), pH, dissolved oxygen (DO), total hardness, chloride, sulfate, nitrate, phosphate, chemical oxygen demand, and alkalinity were measured in triplicate. pH was measured in situ using a pH meter. Dissolved oxygen, alkalinity, sulfate, nitrate, phosphate, chloride and total hardness were determined by titration (Boyd, 1990). Total Dissolved Solids (TDS), chemical oxygen demand (COD) and biochemical oxygen demand (BOD) was determined sequel to APHA (2005). Analysis of different metal ions in the effluent samples was determined by Atomic Absorption Spectrophotometer as per the standard methods (APHA, 2005). Total coliform count was determined by MPN method (WHO, 2014).

Microbiological Analysis

Isolation of microorganism

One mL of water sample was added to 9 mL of sterile distilled water and a tenfold serial dilution was done, and the lower, middle and high dilutions were plated in duplicate into nutrient agar (Himedia, Mumbai), MacConkey agar, and potato dextrose agar plates already prepared. These were incubated at 37°C for 18–24 hrs for total bacteria and coliforms. Colonies on plates were observed and counted and the population density was estimated; bacterial colonies were picked according to their cultural morphology on the plates and these were streaked on new nutrient agar plates for pure colonies (Nwachukwu and Apata, 2013).

Morphological characterization of bacterial isolates

The morphological characteristics of isolates were observed and recorded and this was the basis for the isolation of colonies. The cell shape and arrangements of isolates were determined following the standard procedures of basic stain, gram stain (Nwachukwu and Apata, 2013).

Results and Discussion

In the present study, effluent samples from the metal processing industry were collected and the physicochemical parameters of the effluents were analyzed (Table 1).

Color: The result of the study revealed that the color of the untreated effluent was brownish in color with an offensive odor. A large number of pollutants can impart color, taste, and odor to the receiving water, thereby making them unaesthetic and unfit for domestic consumption (Jamal *et al.*, 2011).

pH

The pH of the samples ranged from 8.8-10.2 so presented in Table-1. Sample SR1 has the lowest (8.8), while sample B has the highest pH value of 10.35. All the pH values were within the permissible limits for industrial effluents set by WHO except sample SR3 and SR5. The pH of samples SR1, SR2, SR4, and SR6 are below the permissible standard for drinking water set by W.H.O while the pH of sample SR3 and SR5 was found to be above the standard.

Total suspended solids TSS

The TSS values (Table-1) of the samples ranged from 63.67- 243.45 mg /L. WHO standard for TSS is 10 mg/l. So it is clear that all the samples have very high TSS values which may be due to the fact that the waste contains many suspended particles. The maximum value of TSS (63.67- 243.45 mg /L) was recorded in the effluent of sample SR3 and SR5.

Total dissolved solids TDS

The TDS values of the samples ranged from 23.34- 894.56 mg/L (Table-1). The lowest value was found in sample SR2 while the highest value was found in sample SR5 and SR6.

Biological and Chemical oxygen demand BOD & COD

The BOD values ranged from 456.56-1931.48 mg/ L as presented in Table-1. The COD values ranged from 585.42-1967.51 mg/. Sample SR2 has the lowest BOD and COD while the sample remaining is having the highest BOD and COD. High COD and BOD concentration observed in the wastewater might be due to the use of chemicals, which are organic or inorganic that are oxygen demand in nature.

Oil and Grease

The average value of oil and grease was 21.6mg/L which is higher than the recommendations of WHO (2003).

Heavy metals

Investigated metals in the industrial effluents of various industries are presented in Table-2. The composition of metals in the wastewater

samples ranged from Cd (0.32- 0.56), Cr (0.08- 4.56), Ni (0.32- 1.43), Pb(0.07- 0.41), Hg(0.06- 0.36), Cu (0.23- 1.43), Zn (0.09- 0.27), Fe (0.37- 1.67), Mg (0.45- 1.12), Mn (0.23- 0.58). The concentrations of metals in the samples analyzed are in the following order Mg> CD> Mn> Ni> Mn> CuZn> Cr> Hg> Pb. The concentration of heavy metals (Pb, Cd and Zn) in all the samples analyzed were far above the maximum permissible level recommended by the WHO

Table.1 Physico-Chemical Analysis of Effluent Samples Collected from different Metal processing Industries (July to December 2018)

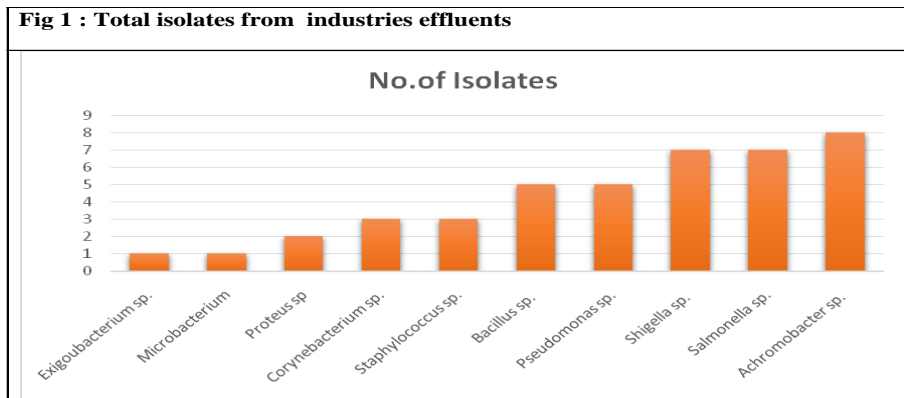
Sample	Colour	pH	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	TSS (mg/L)	DO (ppm)	Oil & Grease (mg/L)	T. coliform (MPN/100 ml)
SR1	Brown	9.2	1726.52	1585.30	584.83	167.34	10.2	17.3	86
SR2	Clear	8.8	456.56	585.42	23.34	75.34	6.8	7.6	40
SR3	Dark	10.1	1852.23	1886.62	495.35	243.45	13.5	21.6	170

Table.2 Physico-Chemical analysis of Effluent Samples Collected from different Metal processing Industries (January to June, 2019)

Sample	Colour	pH	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	TSS (mg/L)	DO (ppm)	Oil & Grease (mg/L)	T. coliform (MPN/100 ml)
SR4	Gray	8.10	787.73	678.93	31.27	63.67	7.3	12.4	63
SR5	Dark	10.2	1931.48	1931.48	894.56	189.45	12.6	20.8	480
SR6	Brown	9.4	1811.56	1774.19	765.98	211.39	9.78	13.6	210
WHO Standard	Clear	6.5 – 9.2	00	20.00	500	10.00	NS	NS	Zero

Table.3 Microbial analysis of Effluent Samples Collected from different Metal processing Industries

Sr. No	Name of isolates	No. of Isolates
1.	<i>Achromobacter</i> sp.	8
2.	<i>Bacillus</i> sp.	5
3.	<i>Shigella</i> sp.	7
4.	<i>Salmonella</i> sp.	7
5.	<i>Pseudomonas</i> sp.	5
6.	<i>Corynebacterium</i> sp.	3
7.	<i>Staphylococcus</i> sp.	3
8.	<i>Proteus</i> sp	2
9.	<i>Exigoubacterium</i> sp.	1
10.	<i>Microbacterium</i>	1
Total isolates		42



The sample SR3 and SR 6 was found more polluted than other sites. Wastewater discharge from metal processing industries is a major component of water pollution, contributing to oxygen demand and nutrient loading of the water bodies, promoting toxic algal blooms, and leading to a destabilized aquatic ecosystem. The presence of oil and grease in the effluent was mainly due to the processing operations. It should be removed since they usually float and affect the oxygen transfer to the water and also objectionable from an aesthetic point of view.

Microbial Analysis

In this preliminary study, the bacterial isolates from the effluent from metal processing industries of the Marathwada region investigated revealed metals resistance strains probably as a result of selective pressure from metal pollution in waste wastewater and this is of public health concern. Thus, there is a need to exploit this opportunity to evaluate them for safety and toxicity to humans, animals, and the environment. The waste discharged from metal processing industries is degradable waste, though it is hazardous to the microorganism in the costal water. The extent of pollution was high as expressed by physicochemical properties. Analysis of industrial effluent discharge showed that the various parameters are beyond the permissible limit. The effluent from two industries shows

acidic pH while the remaining samples have alkaline pH. These values are generally due to the decomposition of the proteinaceous matter and the emission of ammonia.

From fig. 1, it was observed that a total of 6 industrial effluent samples were collected from various industries, shown in fig. 1. From these 6 industrial effluent samples, a total of 42 isolates were obtained and identified on basis of standard morphological, biochemical, and sugar fermentation characteristics by using determinative bacteriology of Bergey's manual. Among these 6 industrial effluent samples, a total of 42 isolates were obtained, among these isolates *Achromobacter* sp. (8), predominantly obtained followed by *Bacillus* sp. (5), *Shigella* sp. (7), *Salmonella* sp. (7), *Pseudomonas* sp. (5), *Corynebacterium* sp. (3), *Staphylococcus* sp. (3), *Proteus* sp. (2), *Exigobacterium* sp. (1) and *Microbacterium* (1).

In conclusion this study, we have been able to relate the ability of microorganisms to survive and develop certain heavy metal resistance capabilities due to selective pressure in the metals pollution in wastewater from metal processing industries. The study can be further extended to investigate the utility of the bacterial isolates recovered in the present study in the bioremediation of metal processing industrial effluents. Overall findings indicated that effluent discharge of

fish processing industries in the Marathwada region is highly polluted and remedial steps should be taken for avoiding water pollution.

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