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PHYSICO-CHEMICAL AND BIOLOGICAL CHARACTERIZATION OF EFFLUENT FROM KMML (KERALA MINERALS AND METALS LIMITED) $T_i O_2$ INDUSTRY, CHAVARA, KOLLAM DISTT., KERALA

B.S.SUMA, C. SHAJI and L. BINDU*
Department of Botany, Sree Narayana College, Kollam — 695 001, Kerala, India.
*Zoological Survey of India, M-Block, New Alipore, Kolkata- 700053, India.
Email: shajisnckollam@gmail.com

Physico-chemical and biological characteristics of KMML industrial effluent were studied for a period of 2 years from September, 2007 to August, 2009. The study was performed to assess the pollution status of the effluent and to find out pollution tolerant taxa, The effluent samples were analyzed for 22 parameters such as Temperature, pH, phenolphthalein alkalinity, total alkalinity, free CO_2, dissolved oxygen, BOD, COD, nitrate, phosphate, sulphate, total dissolved solid, chloride, total hardness, calcium, fluoride, iron, lead, zinc, cadmium, copper and chromium. The results revealed that the effluent contained objectionable amounts of total hardness (30- 2200 mg/l), chloride (42.6-1192 mg/l), sulphate (64.8-561.6 mg/l), phosphate (0.32-2.4 mg/l), TDS (143-3826 mg/l), BOD (11-40 mg/l), COD (260-380 mg/l), iron (9.4-14.2 mg/l), lead (0.2 mg/l) and chromium (0.2 mg/l). A total of 20 algal species were encountered from the effluent. Out of which *Anabaena constricta, Oscillatoria chlorina, O. laetevirens* var. *minimus, O. limosa, O. subbrevis, O. tenuis, Phormidium tenue, Euglena agilis, Cyclotella meneghiniana, Navicula rhyncocephala, Nitzschia amphioxoides* and *Nitzschia palea* have been reported as pollution tolerant species. Thirteen ciliated protozoans were also present in the collections.

Keywords: KMML effluent; Physico-chemical parameters, Pollution tolerant taxa.

Introduction

Rapid industrialization and urbanization has resulted in drastic impairment of our ecosystems. The improper management of waste waters emanating from industries and municipalities may cause serious problems in availability and quality of water[1]. The waste waters near the factories are subjected to reaction with percolating rain water and reach the aquifer system and hence degrade the ground water quality[2]. A continuous periodical monitoring of waste water quality at the emission site is necessary, so that appropriate steps can be taken for waste management practices. Therefore, present study was aimed to analyze the physic-chemical parameters and biological characteristics of the effluent of KMML industry. KMML is located at 8^0 59688' N latitude and 76° 31917'E longitude. The areal extend of KMML is about 210 acres. It is the only integrated plant with mineral separation plant, Synthetic Rutile plant with acid regeneration facility and titanium dioxide pigment productions plant in a single complex.

Material and Methods

The present study was carried out by collecting water and plankton samples from the effluent canal of KMML during the period from September, 2007 to August, 2009 at regular intervals of one month between 9.30 to 10.30a.m. The samples were brought to the laboratory in polythene bottles of 2l capacity. The collected samples were stored at 4°C until the analyses were completed. The atmospheric and surface water temperatures were recorded at the field itself. The pH of the water samples was measured using systronic digital pH meter. Other parameters such as phenolphthalein alkalinity, total alkalinity, free CO_2 dissolved oxygen, BOD, COD nitrate phosphate, sulphate, TDS, chloride, total hardness, calcium, fluoride iron, lead, cadmium, copper, zinc and chromium were analyzed as per the standard methods[3]. Fluoride, lead, cadmium, copper, zinc and chromium were estimated only once i.e. in the samples collected in June, 2009. Fluoride concentration was determined with the help of selective ion meter and heavy metal concentrations were carried out using atomic absorption spectrometry (Per5kin Elner Model-300).

Plankton samples were preserved in 5% formalin. Algae were identified with the help of Standard monographs and research papers[4-6]. Zooplanktons have been identified with the help of standard publications[7,8].

Results and Discussion

The range and average values of various physico-chemical parameters of the effluent are given in Tables 1 and 2. Water temperature varied from 28.3 to 34.8°C and has a close relation to the variation of atmospheric temperature as observed by Sunkad and Patil[9]. pH is one of the most important parameters used in water quality assessment. The permissible limit of pH in water is 6.5 to 8.5[10]. The pH of the effluent ranged from 6.3 to 7.2 with an average of 6.94.

The values of total alkalinity varied from 20 to 240 mg/l, with an average of 75.83 mg/l, which is within the permissible limit of 600 mg/l[11]. Alkalinity itself is not harmful to human beings still the waters with alkalinity less than 120 mg/l are desirable for domestic uses[12]. Phenolphthalein alkalinity was totally absent in the effluent. Free CO_2 was present throughout the study. Its values were found to vary from 4.4 to 13.2 mg/l with an average of 5.75 mg/l. Free CO_2 in water indicates the presence of decomposable organic matters[13,14].

The dissolved oxygen is the most important parameter to check the water quality. In the effluent DO was very low and its concentration fluctuated between 0 to 8.2 mg/l with an average of 2.5 mg/l. The average value was much lower than the desirable limit (5.0 mg/l). Since DO is an index of physical and chemical process going in the water, the presence of oxygen demanding pollutants like organic wastes cause rapid depletion of DO from water[15]. The low DO in the effluent is the most critical manifestation of pollution. BOD is found to be more sensitive test for organic pollution. BOD values ranged between 11 to 40 mg/l with an average of 25.01 mg/l. These higher values indicate high load of organic wastes in the effluent and the average value was beyond the permissible limit for the disposal of waste water. The COD values fluctuated between 260 and 380 mg/l with an average value of 286.2 mg/l. The higher values of COD indicate the presence of oxidizable organic matter in the effluent[16,17]. According to BIS[10] the maximum permissible limit of COD for the discharge of effluents into surface water is 250 mg/l. However, the observed values were beyond this limit.

The nitrate concentration in the effluent lies in the range of 0.42 to 1.9 mg/l with an average of 0.897 mg/l, which is within the permissible limit prescribed by BIS. The concentration of phosphate ranged from 0.32 to 2.4 mg/l with an average value of 0.89 mg/l. The recorded values are higher than 0.1 mg/l, an indication of pollution[18]. The sulphate concentration ranged from 64.8 to 561.6 mg/l with an average of 243.9 which is higher than the permissible limit of WHO (200 mg/l and BIS (150 mg/l). The higher values of sulphate indicate high pollution load in the effluent.

The deterioration of water quality is mainly due to the concentration of TDS[19]. The values of TDS fluctuated between 143 and 3826 mg/l. Its values in the range of 50 to 150 mg/l make the water unfit for any use[20]. The average TDS value was very high (1282.1 mg/l) and exceeded the maximum permissible limit[11]. Chloride values ranged from 42.6 to 1192 mg/l with an average of 292.52 mg/l. Chlorides in water do not cause harmful effects on public health, but high concentration can cause objectionable taste, and it may increase the corrosivity of water. The average chloride concentration in the effluent exceeded highest desirable limit of 250 mg/l and occasionally exceeded the maximum permissible limit as per BIS[10] (1000 mg/l). Hardness of water is mainly due to calcium and magnesium. According to Kannan[21] water with hardness values more than 180 mg/1 is very hard. The total hardness of the effluent varied from 30 to 2200 mg/l with an average of 672.08 mg/l which exceeded the maximum permissible limit (600 mg/l). The calcium concentration fluctuated between 9.62 and 922 mg/l with an average value of 194.09 mg/l. Calcium concentration exceeded the maximum permissible limit of ICMR (200 mg/l) for a few months (February – May 2008; March – May 2008).

Exposure to higher amounts of fluoride causes fluorosis, both dental and skeletal fluorosis[22]. In the effluent its concentration was 0.2 mg/l which lies within the permissible limit. Water with less than 2.0 mg/l iron causes staining of clothes and porcelain and imparts a bitter astringent taste to water[12]. According to Clark[23] iron from titanium dioxide dump sites have no environmental impact, but a cock tail of other metals associated with it causes diverse effect. The average iron concentration (11.1 mg/l) is beyond the maximum permissible limit. The lead content in the effluent (0.2 mg/l) exceeded the maximum permissible limit of 0.1 mg/l for the disposal of industrial waste water. The concentration of cadmium and copper were below the detectable level in the effluent. The observed value of zinc in the effluent was 0.3 mg/l which was within the permissible limit. Chromium has potent carcinogenic effects on human beings[24]. Its concentration (0.2 mg/l) also exceeded the maximum permissible limit.

A total of 20 algal taxa over 9 genera have been recorded from the effluent. Cyanophyceae was found to be the most dominant group, particularly with species of *Oscillatoria*. This observation confirms the view of Palmer[25] who stated that blue greens are very tolerant to pollution. Species of *Oscillatoria* appeared to be well adapted to the pollutants as observed by Taylor *et al*[26]. Among the 20 taxa, *Anabaena constrica, Oscillatoria chlorina,* O. *laetevirens* var. *minimus,* O. *limosa,* O.

Table 1. The range and average values of physico-chemical parameters of effluent from KMML during September, 2007 to August, 2009.

Sl. No	Parameter*		Range	Average
1	Temp. (^0C)	Atmosphere	28.3-34.8	30.17
		Surface water	26.1-33	28.68
2	pH		6.3-7.2	6.94
3	Phenolphthalein Alkalinity		0-0	0
4	Total alkalinity		2.0-2.40	75.83
5	Free CO_2		4.4-13.2	5.75
6	DO		0-8.2	2.50
7	BOD		11-40	25.01
8	COD		260-380	286.2
9	Nitrate		0.42-1.91	0.897
10	Phosphate		0.32-2.4	0.89
11	Sulphate		64.8-561.6	243.9
12	TDS		143-3826	1282.10
13	Chloride		42.6-1192	295.52
14	Total Hardness		30-2200	672.08
15	Calcium		9.62-922	194.09
16	Iron		9.4-14.2	11.1

*All parameters except temperature and pH are expressed in mg/l.

Table 2. Heavy metals and fluoride content in the effluent (June, 2009)

Sl. No	Parameters	Recorded values
1.	Heavy metals (mg/l)	
	a. Lead	0.2
	b. Cadmium	BDL
	c. Copper	BDL
	d. Zinc	0.3
	e. Chromium	0.2
2.	Fluoride (mg/l)	0.2

BDL- Below detectable level.

subbrevis, *O. tenuis. Phormidium tenue, Euglena agilis, Cyclotella meneghiniana, Navicula rhyncocephala, Nitzschia amphioxiodes*, and *Nitzschia palea* have been recorded as pollution tolerant taxa[27,28].

Thirteen ciliated Protozoans viz. *Didinium balbiani, D. nasutum, Coleps hirtus, Lionotus fasciola, Trachelius gutta, Nassula* sp., *Chilodontopsis bengalensis, Microthorax* sp., *Paramecium aurelia, Colpoda cucullanus, Frontonia leucas, Tetrahymena geleii* and *Urocentrum* turbo were encountered from the effluent.

The results of the present investigation revealed that the effluent contained objectionable amounts of total hardness, chlorides, sulphate, TDS, BOD, COD, iron, lead and chromium and low DO. The percolation of the effluent degrades the ground water quality. Therefore, appropriate steps may be taken for the management of waste water.

List of Algal species recorded from the effluent canal:

1. *Anabaena constricta* Szafer
2. *Oscillatoria chlorina* Kuetz. ex Gomont
3. O. *laetevirens* var. *minimus* Biswas
4. *O. limosa* Ag. ex. Gom.
5. O. *raoi* De Toni
6. O. *subbrevis* Schmidle
7. O. *tenuis* Ag. ex. Gom.
8. *Phormidium tenue* (Menegh.) Gom.
9. *Lyngbya stagina* Kuetz.

10. *Euglina agilis* Carter
11. E. *cingula* Gojdics
12. *Trachelomonas* hispida (Perty) Stein var. *hispida* Defl.
13. *Trachelomonas volvocina* Ehr. var. *volvocina* Comforti *et* Tell
14. *Cyclotella meneghiniana* Kuetz.
15. *Navicula capitata Ehr.*
16. N. *rhyncocephala* Kuetz.
17. *Nitzschia levidensis* (W. Smith) Grun.
18. *Nitzschia amphioxoides* Hust.
19. *Nitzschia obtuse W.* Smith var. *scalpelliformis* Grun.
20. N. *palea (*Kuetz.) W. Smith.

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