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Evaluation of Treated Municipal Wastewater Effluent for Agricultural Use

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Abstract—*To decrease the fresh water demand in agriculture and to minimize the amount of wastewater in environment, there is an urgent need for reuse of wastewater. Therefore, the evaluation of treated municipal wastewater from sewage treatment plant located at National Institute of Technology, Rourkela has been performed to check the suitability of reuse in the agricultural purpose by comparing with various national (IS: 2490(1981)) and international (FAO (1994)) standards. In this research paper, the various physico-chemical characterization of treated municipal wastewater effluent has been performed. It has found that total nitrogen and heavy metals (phosphorus and calcium) exceeded the permissible limits mentioned in the standards. These characterized data may be helpful to develop a cost technology for the removal of excess total nitrogen, phosphorus and calcium from the treated municipal wastewater to make the reuse beneficial for agricultural purpose.*

Keywords*: agricultural reuse, effluent, municipal sewage treatment plant*

1. INTRODUCTION

Fresh water availability decreases due to increase of population growth. It has found that 97% of the earth's surface is covered with water, out of which only 2.8 % of fresh water is available for human consumption and agricultural purpose [1].

Presently 65% of the world's population depends on agriculture for their livelihood [2] which account to nearly 88% of total water use, as against of 8% by domestic sector and 3% by industrial purpose [3]. Agriculture accounts for 70% of freshwater withdrawals but wastewater-fed irrigation accounts for only 1% of agricultural water use [4, 5]. But the shortage of fresh water is a major problem for the agriculture. Application of wastewater for agriculture is practiced since the ancient times. Modernization and industrialization enhanced the use of toxic elements into daily life. As a result, use of untreated wastewater for agricultural purpose is not safe. Moreover, production of wastewater is increased rapidly creating problem on disposal. Hence the reuse of treated wastewater for agriculture is one the best option to solve the problems for safe disposal of wastewater and lack of fresh water availability for irrigation.

Reuse of wastewater for agriculture provide nutrients to the soil and plants, recharge the ground water level, increase the productivity of soil and enhance the yield of crops thus helps to improve the country's economy as well as reduce the discharge of wastewater into river [6-9]. Wastewater contains appreciable quantity of chemical and biological characteristics that may be useful for the soil, crops and people, while few species may be harmful. So the identification of that beneficiary and harmful elements of wastewater and their effects are necessary. An attempt has been made to identify the physico-chemical characteristics of treated municipal wastewater that may be useful or harmful in near future for the agricultural purpose.

2. MATERIALS AND METHODS

2.1. Study area

Sewage treatment plant located at National Institute of Technology (NIT) Rourkela has been selected as the study area. The institute is surrounded by hill on the south. Red and laterite soils rich in minerals are found in Rourkela. The city has a tropical climate and receives high southwest rainfall during monsoon (June – September) and retreating northeast monsoon (December – January). Average annual rainfall ranges between160 to 200 cm. The minimum and maximum temperatures are in the range of 7 ^{0} C to 47 ^{0}C.

The selected STP treats municipal sanitary waste from different boy's hostels of NIT Rourkela. The effluent of STP is collected as the sample for the present study.

2.2. Sampling technique

Treated municipal wastewater samples collected from sewage treatment plant (STP) of capacity 0.18 million liters per day (MLD) during 5th June 2015 to 20th October 2015 in air tight bottle of 5 liter. The sampling times are mainly during in peak hours i.e. morning hours (7:00 am to 10:00 am) and evening hours (4:00 pm to 7:00 pm). Biochemical oxygen demand, dissolved oxygen and pH of the sample have been immediately tested and remaining sample has been kept for further physico-chemical characterization. These samples were stored at a temperature below 4^{o}C in the laboratory.

2.3 Characterization of the sample

The detailed physico-chemical characterization have been done according to the IS 3025 by titration and AAS (atomic absorption spectrometer). The analysis techniques have been summarized in table 1.

Table: 1 Method used for Physico-chemical analysis

S.N.	Parameters	Methods used
1.	BOD	IS 3025:part 44:1993
2.	Turbidity	IS 3025: part 10:1984
3.	Total dissolved solid	IS 3025: part 15:1984
4.	Total suspended solid	IS 3025: part 15:1984
5.	Dissolved oxygen	IS 3025:part 38:1989
6.	Alkalinity	IS 3025: part 23:1986
7.	Total hardness	IS 3025: part 21:1983
8.	pH	IS 3025:part 11:83
9.	Total organic carbon	Hach DR/890:10129
10.	Chemical oxygen demand	Hach DR/890:10067
11.	Total nitrogen	Hach DR/890:10071
12.	Fluoride	Hach DR/890:8029
13.	Sulphate	Hach DR/890:8051
14.	Nitrate	Hach DR/890:8039
15.	Residual chlorine	IS 3025:part 26:1986

Heavy metallic analysis (Ca, Mg, Fe, Na, Ni, Cu, Zn, Pb, As, Hg, N, P, and K) are performed by using atomic absorption spectrophotometer (Perkin Elmer Analyst 200) as per guidelines of MHS (Perkin Elmer, 2006).

3. RESULTS AND DISCUSSION

Some specific properties of wastewater are relevant in yield and quality of crops, protection to environment and maintenance of soil productivity. Detailed physical and chemical characterizations have been performed to evaluate the quality of wastewater for its reuse in agriculture. These characterized data have been compared with national standard (IS: 2490(1981)) [10] and international standards (FAO (1994)) [11] as summarized in table 2. The IS: 2490(1981) basically gives the tolerance limits for reuse of industrial effluent in agriculture. In this study, IS: 2490(1981) has been followed for reuse of treated municipal wastewater effluent in agricultural purpose. The tolerance limit of treated municipal wastewater effluent comes under the range of tolerance limits for industrial effluent for the agricultural purpose.

Table 2: Physico-chemical properties of treated wastewater from STP and comparison with parameters required for agriculture purpose

S.N.	Parameter	Unit	Obtained value			Permissible limit	
			Average	Max.	Min.	IS:2490 (1981)	FAO (1994)
1.	BOD	mg/l	16.95	18.35	15.98	30	NA
2.	pH	-	7.02	8.02	6.36	5.5-9	5.5-9
3.	Turbidity	NTU	7.50	12.50	1.01	10	NA
4.	Residual Chlorine	mg/l	0.01	0.02	-	NA	NA
5.	Alkalinity	mg/l	368.42	425	305	NA	NA
6.	Total Dissolved Solid	mg/l	524.14	790	345	2100	NA
7.	Total Suspended Solid	mg/l	0.05	0.10	.0036	100	NA
8.	Dissolved Oxygen	mg/l	5.58	6.00	5.10	NA	NA
9.	Total Hardness	mg/l	190.14	210	152	NA	NA
10.	Total Organic Carbon	mg/l	15.01	18.90	10.10	NA	NA
11.	Chemical Oxygen Demand	mg/l	68.44	115	-	250	NA
12.	Total Nitrogen	mg/l	16.75	27.50	0.98	NA	1-10
13.	Nitrate	mg/l	0.22	0.40	0.03	NA	5-50
14.	Sulfate	mg/l	13.22	19	3	1000	30-90

Plant toxicity problems may occur if higher concentrations of physico-chemical parametres and heavy metals present in the treated municipal wastewater effluent is above threshold values. Hence, the concentration of these parameters will have to be determined before reusing in agricultural purpose. In this study, turbidity, total suspended solids and total dissolved solids are within the specified range of the standards. Alkalinity, residual chlorine, dissolved oxygen, hardness and total organic carbons of wastewater effluent were determined but the permissible limits of these parameters are not available in any of the two given standards. While pH, biological oxygen demand, chemical oxygen demand , total nitrogen, sulphate and nitrate were also evaluated and found within the range of permissible limits as per given in the standards.

Heavy metals are a special group of trace elements which have been shown to create definite health hazards when taken up by plants. They are not normally included in routine analysis of regular irrigation water, but attention should be paid to them when using sewage effluents, particularly if contamination with industrial wastewater discharges is suspected. These include fluoride (F) and iron (Fe) as summarized in table 3.It has been found that the obtained values of these parameters are within the given range mentioned of standards.

Table 3: Heavy metals presents in treated wastewater from STP and comparison with parameters required for agriculture purpose

S. N	Parameter	Unit	Measured value of treated wastewater effluent			Standards and permissible limits	
			Average	Max.	Min.	IS:2490 (1981)	FAO (1994)
1.	Ca	mg/l	23.59	27.33	17.94	0-20	100
2.	Mg	mg/l	2.98	3.07	2.91	0-5	0.20
3.	Fe	mg/l	0.27	0.58	0.05	NA	0-5
4.	Na	mg/l	3.16	3.22	3.09	0-60	NA

5.	Ni	mg/l	-	-	-	0.3	0.2
6.	Cu	mg/l	-	-	-	3	0.2
7.	Zn	mg/l	0.04	0.06	0.03	5	NA
8.	Pb	mg/l	0.006	0.01	-	0.1	NA
9.	As	mg/l	-	-	-	0.20	0.1
10.	Hg	mg/l	0.0007	0.001	-	0.01	NA
11.	P	mg/l	49.52	53.12	45.95	NA	0.1-0.4
12.	F-	mg/l	0.25	0.75	-	2	1
13.	K	mg/l	4.34	1.12	1.02	NA	5-20

In the heavy metallic analysis Cu and As were not identified. The physico-chemical and heavy metallic properties of the treated wastewater effluent are very important for the agricultural purpose as it affect the soil, crops and human being directly and indirectly. Further investigation of these properties in details is required for its reuse in agriculture. It provides micro nutrients i.e., boron (B), zinc (Zn), manganese (Mn), iron (Fe) and copper (Cu), while primary macro nutrients such as nitrogen (N), phosphorus (P), potassium (K), and secondary macro nutrients like calcium (Ca) and magnesium (Mg) that are necessary for growth of plants and health of soil. But excess in amount may affect the soil and plant growth. As a result, it is necessary to remove the excess primary macro nutrients (total nitrogen, calcium and phosphorus) and bring within the permissible limit as per given by the standards. But it is observed that the permissible limit of calcium is given different in IS 2490(1981) and FAO (1994). Hence, IS2490 (1981) has been considered for the comparison of obtained value of calcium of municipal treated wastewater effluent.

4. CONCLUSION

After performing the physico-chemical characterization and heavy metallic analysis of treated municipal wastewater, it can be conclude that the quality of treated municipal waste water effluent plays a significant role when applied to soil and crops. In the treated municipal wastewater effluent from STP of NIT Rourkela, it is observed that the value of total nitrogen, calcium and phosphorus is more than the permissible limit as required for the sustainable agriculture given as per the IS 2490(1981) and FAO(1994) . As a result, total nitrogen, calcium and phosphorus need to be treated before using the effluent for agricultural purpose.

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