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Physicochemical Properties and Fertilizer Value of Sewage Sludge

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Abstract: The aim of the study was to assess the physic-chemical properties and fertilizer value of sewage sludge generated in Gwalior M.P. In order to achieve this objective water samples were collected from ten sites and analyzed for different parameters. The analysis was done for the parameters like temperature, pH, electrical conductivity, turbidity, total suspended solids, alkalinity, chloride, free CO_2, hardness, dissolved oxygen, total dissolved solids, organic matter, phosphoric acid, nitrogen and potassium. The use of the sewage sludge on agricultural land provides an alternative for its disposal. The results revealed that the sewage sludge may be used as fertilizer in agricultural fields, vegetable gardens etc., however, further research is needed to identify the toxicity of sewage sludge generated in Gwalior.

Key words: Sewage sludge · Physic-chemical properties · Fertilizer value · Agricultural land toxicity

INTRODUCTION

The sewage sludge is a product derived from the treatment of municipal wastewater. The treatment process consists of the settling of solids and partial biological decomposition. Flocculation of suspended solids and dissolved ions, secondary aerobic or anaerobic digestion, filter press or centrifuge de-watering, composting, lime stabilization, or heat stabilization of the de-watered sewage sludge are some of the additional process for the treatment of sewage water [1]. Septic sludge is the waste from septic tanks which are cleaned out periodically to prevent septic disposal beds from clogging. Septic tank wastes are transported to settling lagoons; as they reach to their capacity and the solids from these lagoons are removed periodically. The sewage sludge and septic sludge solids may be disposed of in a landfill or an incinerator, or applied to agricultural land, or co-composted with a bulking agent or other organic waste [2]. This process may reduce the amount of sewage and help in minimizing various environmental problems that may occur by the use of synthetic fertilizer in agricultural areas to some extent. The high content of organic matter and substantial nitrogen and phosphorus concentrations makes it feasible, as a fertilizer in agriculture or as a regenerator for soil in the most cost-effective manner [3].

Recently it has been reported that the ashes from sewage sludge incineration are rich in phosphorus content and the possible three-stage processing of SSA (Sewage Sludge Ash), may extract 90% of the phosphorus that is used to make an adequate phosphate fertilizer [4]. The present study was undertaken to analyze the fertilizer value of the sewage sludge generated from the residential areas of the Gwalior city.

MATERIALS AND METHODS

The sewage water comes from different residential areas of Morar, DD Nagar and Army cantonment which are being treated by the sewage treatment plant located at Morar Laltipara, Gwalior M.P. India. The samples were taken regularly for a period of ten weeks during summer season only, at each site, five samples were collected during morning and evening hours following the standard methods of Theroux *et al*, [5]. The pH, temperature and Dissolved Oxygen (DO) were determined and recorded immediately in the laboratory. The temperature, pH, conductivity and turbidity was determined by using thermometer, digital pH meter MKVI-8611 (Systronics), digital conductivity meter model CC 601(Systronics) and Nephelo-Turbidity Meter 131., SR.NO 1984 (Systronics), respectively. The Dissolved Oxygen (DO) was determined by using the Wrinkler's Method [6]. The chloride was determined by argentiometric method, The Total Solids (TS), Dissolved Solids (DS) and Suspended Solids (SS) were estimated gravimetrically [5]. The organic matter, phosphoric acid, nitrogen and potash of the sewage was determined by the standard methods of Theroux *et al.*, [6].

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Pearson's coefficient of correlation was used to calculate relationship between different parameters. Statistical analysis was done with the help of SPSS computer programme.

RESULTS AND DISCUSSION

The temperature and pH of the sewage water ranged from 32-38°C and 8-8.9, respectively, as shown in Fig. 1 and 2. Temperature readings are helpful in the calculation of various forms of alkalinity and are useful in detecting an unsuspected source of pollution. The high temperature in the sewage may be attributed to the natural biodegradation process that takes place in the sewage due to the presence of various types of organisms. Dissolved gases present in the sewage may exert an influence on the pH of water. Most waters are slightly alkaline due to the presence of carbonates and bicarbonates. Bhatt *et al.*, [7] observed pH 7.5 in Kistobazar nalla in West Bengal which is polluted by sewage effluents, however, in our study the pH value was slightly alkaline. pH showed moderate positive correlation with electrical conductivity (r = 0.8351), total suspended solids (r =-0.4306), alkalinity (r =-0.1748), free carbon (r =-0.7029), exhibited the moderate negative correlation with temperature.

The electrical conductivity of the sewage water ranges between 2.12-2.76 dS/m as shown in the Fig. 3. The conductivity, thus serves as a good and rapid measure of the total dissolved solids in water. Sharma [8] observed conductivity ranging from 462 to 1518 m.mhos.cm^{-1} at sewage channel Swarna Rekha flowing through Gwalior city. The electrical conductivity (EC) of the water samples ranged between 2.12 and 2.76 dS/m. It was discovered that the mean of EC of all the sewage water samples was 2.48 ± 0.06 dS/m. Electrical conductivity showed the positive correlation with turbidity (r = 0.1682), free carbon (r = 0.6849), dissolve oxygen (r = 0.5879) while, total soluble solids (r =-0.2764), chloride (r =-0.2262), hardness (r =-0.2482) exhibited significant negative correlation with electrical conductivity.

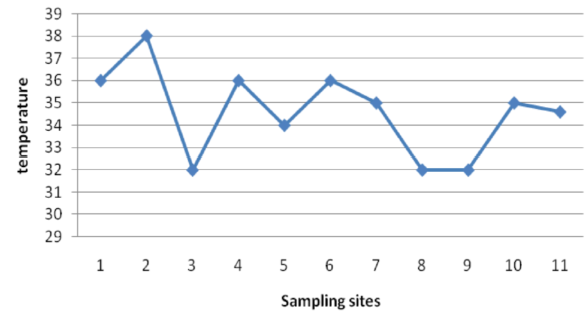

Fig. 1: Temperature (°C) of the sewage

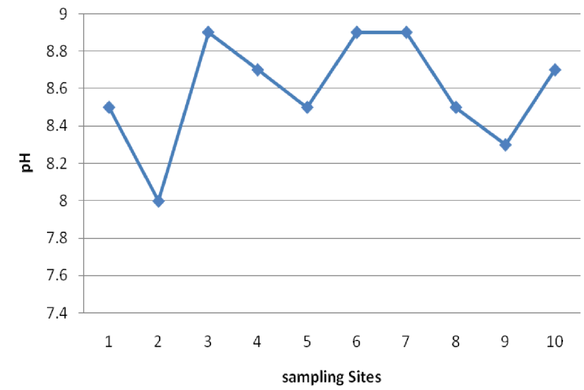

Fig. 2: pH of the sewage water

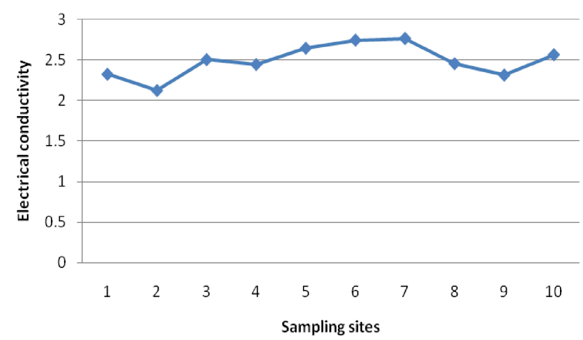

Fig. 3: Electrical conductivity (dS/m) of the sewagw water

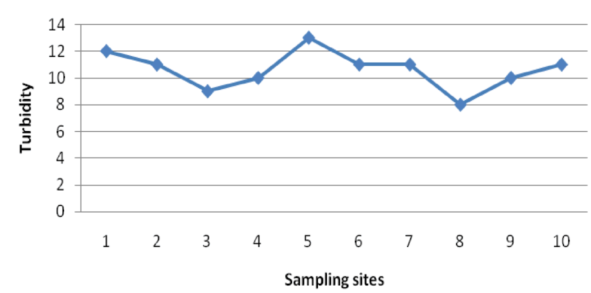

Fig. 4: Turbidity (NTU) of the sewage water

The turbidity of the sewage water ranged between 8-13 NTU as shown in the Fig. 4. The turbidity of any water sample is the reduction of transparency due to the presence of particulate matter such as lay or silt, finely divided organic matter, plankton and microscopic organisms. The turbidity ranged between 9-13 NTU and the mean of all the samples was 10.6 ± 0.45 NTU. Turbidity showed significant positive correlation with total suspended solids (r = 0.2728), total alkalinity (r = 0.4544), free carbon (r = 0.6849), hardness (r = 0.2717) while, chloride (r =-0.3148), dissolved oxygen (r =-0.2751) exhibited the moderate negative correlation.

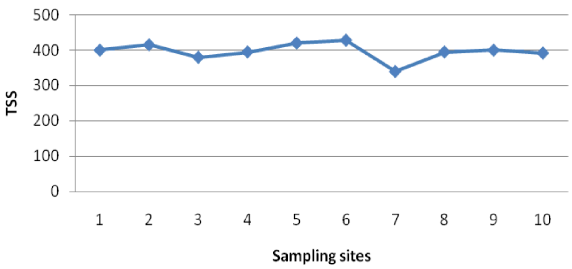

Fig. 5: Total Suspended (mg LG^1) Solids of the sewage water

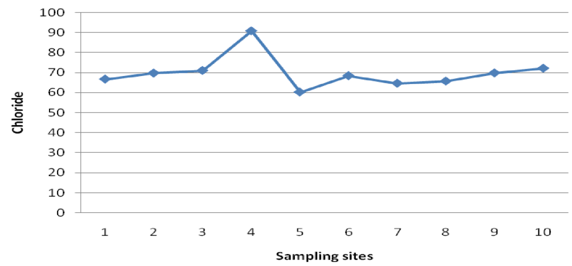

Fig. 7: Chloride (mg LG^1) of the sewage water

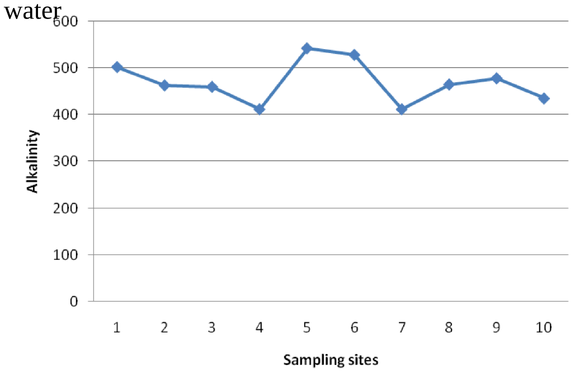

Fig. 6: Alkalinity (mg LG^1) of the sewage

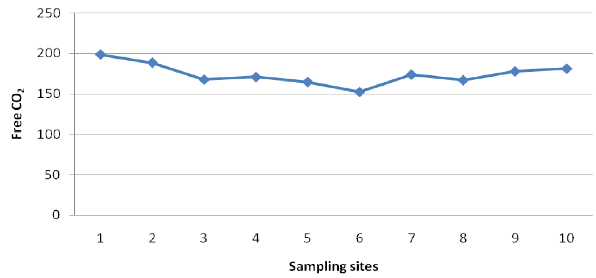

Fig. 8: Free CO_2 (mg LG^1) of the sewage water

The suspended solids determination is particularly useful in the analysis of sewage and other waste and is as significant as BOD determination. It is used to evaluate the strength of domestic wastewaters and efficiency of treatment units. The total suspended solids (TSS) in the water samples are within the range 380-428 mg LG^1 and the mean concentration of suspended solids are 396.50 ± 7.75 mg LG^1 (Fig.5) which is below the permissible limits (600 mg LG^1) for the public sewers. Total suspended solids showed positive correlation with alkalinity (r = 0.7375), hardness (r = 0.2213), while, chloride (r =-0.0244), free carbon (r =-0.1504) exhibited the moderate negative correlation. Total alkalinity showed positive correlation with chloride (r = 0.5715), hardness (r = 0.2320), while free carbon (r =-0.2221), dissolved oxygen (r =-0.1255) exhibited the moderate negative correlation.

The alkalinity of the sewage water ranged between 412-542 (mg LG^1) as shown in Fig.6. The determination of alkalinity provides an idea of the nature of salts present in water. If the alkalinity is equal to hardness, only calcium and magnesium salts are present. If the alkalinity is greater than hardness, it indicates the presence of basic salts viz. Na and K in addition to those of Ca and Mg. When the alkalinity is less than the hardness, neutral salts of calcium and magnesium must be present that are not carbonates, but the sulphate. It has been reported that the high values of alkalinity in river Ganga at Varanasi and river Gomati at Jaunpur are due to the discharge of domestic sewage and industrial effluents into these rivers [9] and in our study we have observed high alkalinity values in the sewage which may be due to the presence of high salt content in the sewage water.

The chloride content of the sewage water ranged between 60.2-90.8 (mg LG^1) as shown in Fig. 7. Chlorides in water generally occur as salts of sodium, potassium and calcium. Chloride concentrations of sewage are directly related to population density and fecal coliform counts [10]. The high levels of chloride indicate the contamination by human and other activities [11]. However chloride is a conservative chemical species that generally does not degrade in natural ground water, is not readily removed through natural soil treatment and travels faster than other less conservative chemicals in unsaturated zone and aquifer system [12]. Chloride showed positive correlation with free carbon (r = 0.0133), while hardness (r =-0.2297) exhibited the moderate negative correlation.

The amount of CO_2 present in the sewage depends on the temperature, pressure and mineral contents of the water. Verma [13] observed free CO_2 moderately in river Subernarekha at Ghatsila where the river receives huge untreated effluents. However, in this study the free CO_2 ranged between 152.6-198.8 mg LG^1 and mean of all the samples is 174.44 ± 4.13 mg LG^1. Free Carbon showed positive correlation with dissolved oxygen (r = 0.2517) while hardness (r =-0.1047) exhibited the significant negative correlation.

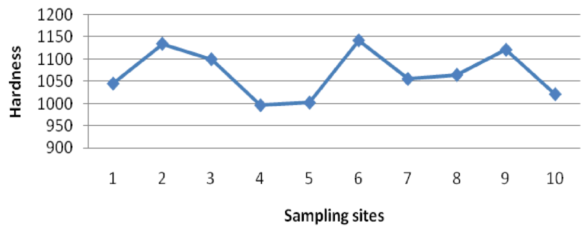

Fig. 9: Hardness (mg LG^{1}) of the sewage water

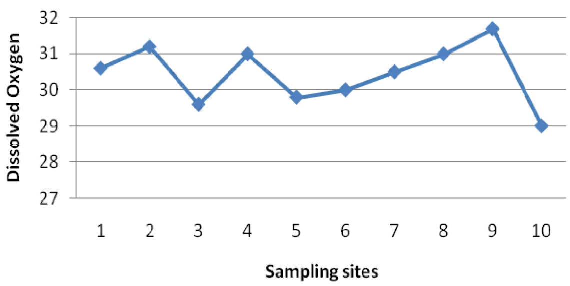

Fig. 10: Dissolved oxygen (mg LG^{1}) of the sewage water

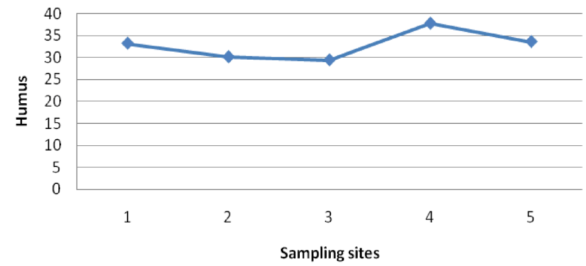

Fig. 11: Humus content (%) of the sewage Sludge

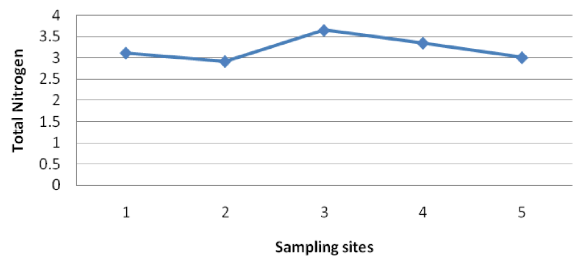

Fig. 12: Total Nitrogen of the sewage sludge

Total Hardness of water is characterized by contents of Ca and Mg salts. Hardness of water varies considerably from place to place and depends upon the various factors. The principal cations that contribute to the hardness are Ca and Mg, whereas, Fe, Al, Mn, Sr and Zn also contribute a little to the hardness. In the present study the hardness values were found to be high in the sewage water, which might be attributed to the presence of high nutrients like phosphates and nitrates in the sewage. The hardness of sample ranges from 997.2-1142 mg LG^{1} and mean of all the samples ranged between 1068.64 ± 16.91 mg LG^{1} Fig. 9.

Dissolved oxygen is one of the important parameter in water quality assessment. It was observed that the mean value of dissolved oxygen ranged from1.8 mg LG^{1} to 5.9 mg LG^{1} of river Ganga at Varanasi. The highest DO was found at minimum pouring sites where sewage was discharged into the stream and less human activity was taking place [14]. Shyamala *et al.*, [15] noticed anoxic condition with absence of dissolved oxygen at Kalingarayan canal near Erode district due to heavy sewage loads at this canal. The dissolved oxygen ranges from 29-31.7 and the mean of all the samples 30.44 ± 0.26 mg LG^{1} Fig.10.

The humus content of the sewage sludge ranged between 29.4-37.8 %. as shown in the Fig.11. Application of organic matter to the soil improves the physical properties of soil by increasing the retention capacity of minerals and water and improvement in the soil bearing strength by reducing the surface runoff and water erosion. Organic matter is an energy source for various types of soil dwelling micro-organisms and therefore, the sewage with rich content of organic matter may be used as fertilizer in agriculture land for improving its fertility.

The amount of nitrogen in the sewage sludge varies between 2.9 and 3.65 % (Fig.12), the nitrogen availability depends on the type of sludge. but within one type of sludge, great variations have been found by us (Table 1). The different treatments carried out on sludge may also greatly influence the availability of the nitrogen in the sludge, without knowing the influence of each one of them [16]. The temperature, humidity, pH and texture of the soil and condition of land spreading are the factors that influence the accessibility of the nitrogen. The loss of nitrogen may represent a possible risk of groundwater pollution if volatilization of the ammonia takes place, or if nitrates are leached. This process generally occurs when the amount of sludge applied does not correspond to plant needs or because of the fast degradation of sludge-borne organic matter [17]. Nitrogen exhibited significant positive correlation with potash ($r = 0.83$) and phosphoric acid showed positive correlation with potash in the present investigation.

The phosphoric acid content of the sewage sludge ranged between 1.20-1.56 % as shown in the Fig.13. Phosphorus is used by the plant for its growth, the rigidity of its cell walls and for the development of its root system. Sludge-borne phosphorus is of particular interest as phosphorus is a limited natural resource. Phosphorus in sludge is mostly present under mineral form: mineral phosphorus can represent between 30 and 98 % of the total phosphorus, according to the type of sludge.

Table 1: Physico-chemical properties and fertilizer value of sewage water

Parameter	I	II	III	IV	V	VI	VII	VIII	IX	X	Mean*	Range
Temp°C	36	38	32	36	34	36	35	32	32	35	34.6	32-38
Odor	Foul	Foul	Foul	Foul	Foul	Foul	Foul	Foul	Foul	Foul	-	Foul
pH	8.5	8.0	8.9	8.7	8.5	8.9	8.9	8.5	8.3	8.7	8.59 ± 0.09	8.0-8.9
E.C(dS/m)	2.32	2.12	2.5	2.44	2.64	2.74	2.76	2.45	2.31	2.56	2.48 ± 0.06	2.12-2.76
Turbidity (NTU)	12	11	9	10	13	11	11	8	10	11	10.6 ± 0.45	9-13
T.S.S (mg L^{-1})	400	415	380	395	420	428	340	395	400	392	396.5 ± 7.75	380-428
Alkalinity (mg L^{-1})	502	463	460	412	542	528	412	465	478	435	469.7 ± 14.05	412-542
Chloride (mg L^{-1})	66.7	69.71	71.0	90.88	60.2	68.4	64.6	65.7	69.8	72.1	70.81 ± 3.41	60.2-90.8
Free Carbon (mg L^{-1})	198.8	188.7	167.9	171	164.9	152.6	174	167.2	178	181.3	174.44 ± 4.13	152.6-198.8
Hardness (mg L^{-1})	1045.6	1134.6	1100	997.2	1003	1142	1056	1065	1121	1022	1068.64 ± 6.91	997.2-1142
D.O (mg L^{-1})	30.6	31.2	29.6	31	29.8	30	30.5	31	31.7	29	30.44 ± 0.26	29-31.7
Humus (%)	-	33.2	-	30.1	-	29.4	-	37.8	-	33.6	32.82 ± 1.49	29.4-37.8
Total Nitrogen (%)	3.12	-	2.92	-	3.65	-	3.35	-	3.01	-	3.21 ± 0.13	2.92-3.65
Phosphoric Acid (%)	-	1.42	-	1.3	-	1.56	-	1.33	-	1.2	1.36 ± 0.06	1.2-1.56
Potash (%)	0.3	-	0.21	-	0.28	-	0.3	-	0.20	-	0.26 ± 0.002	0.20-0.30

*Data expressed as mean±1SEM, with all values given in mean value of the parameters

It has also been observed that composted sludge has lower phosphorus content than non-composted sludge, due to the low phosphorus content of the co-products used during the composting process.

When sewage sludge is applied to agricultural land, the sludge usually does not provide enough K to meet the requirements for forage and corn growth even though the availability of K in septic waste and sewage sludge is rated very high [18, 19]. High applications of Ca and Mg in organic amendments or lime can reduce K availability; consequently, additional K would have to be applied as synthetic fertilizer [2]. The amount of potash in the sewage water was found to be 0.20-0.30% (Fig. 14) which is an indication that the sewage may be used for the irrigation purposes.

The study concludes that the sewage sludge may be used as fertilizer in agricultural fields, vegetable gardens etc. However, further research is needed to identify the toxic substances present in the sewage. The treatment facilities may provide a path and may help in reducing the toxicity of the sewage water of the study area.

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