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ORIGINAL ARTICLE

Chemical and Microbial Composition of Municipal Sewage water around Hubli-Dharwad in Karnataka

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ABSTRACT

A study was conducted at UAS Dharwad campus and two other sites near Hubli city during 2013-2014 to characterize the chemical constituents and microbial composition of sewage water and also to study the seasonal variations in the composition. The water samples were collected at a monthly interval for a period of one year from the three sites. The parameters like pH, BOD, COD, total nitrogen, calcium and magnesium in sewage water showed lower concentration in monsoon season compared to winter and summer. The pH of the sewage water was slightly alkaline (6.97 to 7.47) and EC was well below 2 dS m^{-1}. The BOD and COD values ranged from 344 to 415 mg L^{-1}, 492 to 525 mg L^{-1}, respectively. Among the cations, sodium concentration was above the permissible level for irrigation and the cationic concentration was in the order of Na>Ca>Mg>K. The chloride and bicarbonate concentration was higher in the sewage water suggesting slight to moderate restriction for irrigation. The seasonal concentration of micronutrients did not vary much and were within the permissible levels for irrigation. The heavy metals (Pb, Cd and Cr) were not detected in sewage water. The preponderance of the microflore in the sewage water followed the order: bacteria > fungi > actinomycetes. The highest counts were obtained during the monsoon season followed by winter and the least in summer. The counts of pathogen, E.coli varied in narrow range of 4-6 CFUx10-3 ml in the three sites. However, E. Coli was not traced in the ground water nearby suggesting no contamination with sewage water.

Key words: Muncipal sewage water, Characterization, seasonal variations, microbial count, ground water quality

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INTRODUCTION

The major environmental concern in urban India relates to high levels of water pollution due to poor waste disposal, inadequate sewage treatment facilities and improper disposal of sewage water. Fecal contamination may also occur in the domestic waste water as there are less community facilities for waste disposal and also collection and treatment facilities are inadequate or improperly operated. The domestic sewage consists of waste water from kitchen, bathrooms, toilets etc. The solid part of the sewage water is mostly organic materials like food wastes, kitchen washings etc., and these are putrefactive in nature. Thus the sewage can be considered to be a mixture of waste waters and certain amount of organic and inorganic materials in dissolved, suspended and colloidal states.

The sewage water contains essential nutrients and possesses properties which can easily be utilized for irrigating the field and perennial crops. But the sewage water of many cities where industrial effluent is mixed in the sewage system contained toxic metals. There is a need for continuous monitoring of quality of sewage available in the country and their impact on soil health is required in order to make use of sewage waters as a cheap potential alternative source of plant nutrients in agriculture.

A study was conducted at three locations; one at the University of Agricultural Sciences (UAS) campus and the other two in villages near Hubli with an objective of characterizing sewage water and to assess the seasonal variations in its composition and also to ascertain the quality of ground water nearby.

MATERIALS AND METHODS

The Hubli-Dharwad Municipal Corporation is the second largest in Karnataka State. next only to Bangalore. About 60 million litres of waste water is being generated every day in these twin cities which is being utilized by the farmers for growing various crops like vegetables, cotton, maize, sugarcane, pulses *etc* in *rabi* and summer season. The only source of water during summer is the sewage water and therefore cropping is very much restricted. Hence, there is a greater demand for sewage water [1]. Similarly, at UAS, Dharwad, about 150000 litres of raw domestic waste water is generated from the campus.

The climate of Hubli and Dharwad is semi-arid with an average annual rainfall of 711 and 780 mm, respectively. The sewage water samples were collected at monthly intervals (February'13 to January'14). The water sample from a well also collected from Mavanur village to study the ground water contamination.

The sewage water samples were collected in plastic cans by employing the grab sampling method [2]. The samples thus collected were brought to the laboratory and were refrigerated at 4^0C immediately and analysed subsequently. The ground water samples near the sewage water stream in Mavanur village was taken during the month of September by grab sampling method and analysed for the various quality parameters. The dissolved solids in the samples were determined by gravimetric method and suspended solids by filtration method [3]. The biological oxygen demand (BOD) of water samples was determined by Wrinkler's method and the chemical oxygen demand (COD) by Open reflux method [3]. Micronutrients and heavy metals (Fe, Zn, Cu, Mn, Pb, Hg, Cd and Cr) in the water samples were measured by using ICP-OES. The filtered water samples were acidified with 1 ml of conc.HNO_3 and the samples were fed to the ICP-OES [4]. The bacteria, fungi, actinomycetes and *E.coli* count in sewage waters was determined by using serial dilution and standard plate count technique [5]. The other estimations for the characterization of sewage and water were carried out by following standard procedures [3].

The monthly data was averaged over the three seasons *viz*., summer (February to May), monsoon (June to September) and winter (October to January) and presented in different tables.

RESULTS AND DISCUSSION

Chemical characteristics of sewage water:

Seasonal variation in the concentrations of different parameters of sewage water like pH, BOD, COD, total nitrogen, calcium and magnesium were noticed (Table 1). Lowest concentrations of the above said parameters recorded during monsoon which could be due to dilution of sewage water with rain water during the monsoon. Similar seasonal variation in the characteristics of sewage water was reported by Som *et al.* [6]; Antil and Narwal [7].

pH and EC:

The sewage water was slightly alkaline in nature in all the locations (6.97 to 7.47) and it falls within the safe limits of 6-8.5 [8] for irrigation. The highest pH was recorded in winter season in all the three villages which could be due to the precipitation of bicarbonates in the sewage water during the season. The EC of sewage water was well below 2.0 dS m^{-1} in all the three sites and falls under the category of good quality irrigation water as per the classification of CSSRI, Karnal [9].

Total solids, Total suspended solids and Total dissolved solids:

Total solids were relatively higher at Gabbur (1126 mg L^{-1}) and UAS, Campus because these places are starting points of sewage water stream and lower at Katnur (1098 mg L^{-1}), which could be due to the farther distance of Katnur from the sewage outlet in comparison to Gabbur and so more sedimentation of particles happened in Gabbur. It was higher during winter season in all three locations. Similar trend was observed with respect to total suspended solids. In all the three locations, the annual average concentration of TSS (291 to 402 mg L^{-1}) was above the permissible limit of 200 mg L^{-1} in all the seasons as prescribed by standards of CPCB [20] for effluents. The TDS (731 to 872 mg L^{-1}) in the sewage water was higher than the permissible limit of 450 mg L^{-1} as per FAO [10]. However, the values are well below the prescribed maximum concentration of 3000 mg L^{-1} in irrigation water as per criteria of FAO [11] suggested for effluents to be discharged on land.

BOD and COD:

Based on the BOD (328 to 415 mg L^{-1}) and COD (398 to 525 mg L^{-1}) values, the raw sewage water can be rated as unsuitable for irrigation purposes when compared to prescribed limits of 100 mg L^{-1} [11] and 500 mg L^{-1} [13] for BOD and COD, respectively as reported by Yadav *et al.* [14]. High concentration of organic matter in sewage water is reflected by its high BOD values [11]. Irrespective of the locations, the lowest seasonal averages were recorded during the monsoon season. This could be due to dilution of sewage water with fresh water from rains.

Cations and anions:

Sodium was the dominant cation which is slightly higher (5.38 to 6.48 me L^{-1}) than recommended level of 4 me L^{-1} [11] and the cationic composition is in the order of Na>Ca>Mg>K. The concentration of Ca (3.63 to 4.76 me L^{-1}) and Mg (2.90 to 3.73 me L^{-1}) were below the maximum permissible level (7.5 to 10.0 me L^{-1}) as per WHO [12] for the use of sewage water for irrigation. Lower concentration of these ions except sodium was recorded in monsoon season. However, the sodium concentration was found higher in monsoon season which could be due to run off from the agricultural fields where the plant protection chemicals are applied contribute for the source of sodium in sewage water.

The chloride concentration was high (7.3 to 8.0 me L^{-1}) affecting the irrigation water quality. The chlorides are higher than recommended level of 4 me L^{-1} [11] which falls under the category of slight to moderate restriction for irrigation. Higher concentration was recorded in the summer season and then there is a steady decrease in monsoon and winter season and there is more variability in Gabbur than in the other two villages which could be due to the dilution effect of rain water. The concentration of chloride was more than recommended for foliar application to some crops such as almond, plum as reported by Mass [16] where as it can be used for sprinkler irrigation for some crops like corn, alfalfa, safflower, sesame, sorghum, cauliflower, cotton *etc*.

The bicarbonate concentration was quite high (7.72 to 8.22 me L^{-1}) enough to be toxic as they exceed the recommended level of 1.5 me L^{-1} [12]. The bicarbonate concentration was more than the recommended for irrigation and the use of such water for irrigation may cause white patches on fruits, flowers and leaves which will reduce their marketability. Alkalinity of the sewage water was due to bicarbonates alone. The Ca and Mg concentration offsets the bicarbonates thus resulting in RSC values less than 2.5. The sewage waters can be grouped as of good quality irrigation water as per the classification by Minhas and Gupta [9].

Across the locations, the sulphate concentration was lower in the sewage water in all the three seasons (6.60 to 7.47 mg L^{-1}) and it was within the maximum permissible level of 42 - 45 mg L^{-1} as per FAO [15].

Nitrogen and Phosphorus:

Total N in sewage water increased during summer and decreased during monsoon season which may be due to dilution effect. The higher total nitrogen in sewage water (19.74 to 20.35 mg L^{-1}) could be due to the presence of organic compounds like urea, proteins, aminoacids and ammonical nitrogen resulting from bacterial decomposition of organic constituents which are the major source of nitrogen [17]. High levels of phosphates (16.4 to 17.4 mg L^{-1}) were observed, irrespective of place and time of sampling which could be due to use of large amounts of detergents by the households in Hubli city. Sreeramulu [18] indicated that the presence of phosphorus in the sewage mostly due to detergents and food residues and their breakdown products. The phosphate content exceeded the prescribed limits of 5 mg L^{-1} [13] in all the seasons.

Table 1: Chemical composition of sewage water at UAS, Dharwad and Gabbur and Mavanur

Parameter		UAS Dharwad				Gabbur				Mavanur				
	unit	Summer	Monsoon	Winter	Annual	Summer	Monsoon	Winter	Annual	Summer	Monsoon	Winter	Annual	Groundwater
pH		7.17	7.31	7.33	7.27	7.30	7.23	7.51	6.79	7.39	7.50	7.50	7.47	7.70
EC	dS m-1	1.38	1.36	1.30	1.35	1.20	1.26	1.24	1.14	1.19	1.31	1.27	1.26	0.95
Total solids	mg L^{-1}	1143	1191	1164	1166	1148	1199	1313	1220	1008	1114	1235	1119	-
TSS	mg L^{-1}	305	302	272	293	383	430	494	436	295	378	426	366	80
TDS	mg L^{-1}	838	887	892	872	765	798	813	792	713	823	804	780	420
BOD	mg L^{-1}	375	290	320	328	584	379	385	449	447	307	384	379	96
COD	mg L^{-1}	526	338	332	399	646	471	556	558	568	448	559	525	280
Ca	me L^{-1}	4.62	4.73	4.92	4.76	4.40	3.27	4.16	3.94	4.43	3.14	4.13	3.09	5.4
Mg	me L^{-1}	3.95	3.85	3.39	3.73	3.90	2.70	2.80	3.13	3.89	2.40	2.98	3.9	2.7
Sodium	me L^{-1}	5.45	7.68	6.31	6.48	5.00	7.25	5.30	5.4	5.55	7.45	5.75	6.2	6.5
Potassium	me L^{-1}	0.62	0.63	0.54	0.60	1.20	0.66	0.57	0.76	1.27	0.60	0.53	0.80	0.03
Chloride	me L^{-1}	7.05	7.76	8.19	7.67	8.7	8.1	7.0	7.8	8.5	7.8	7.1	8.0	5.0
Sulphate	me L^{-1}	6.70	7.66	7.63	7.33	7.50	7.30	6.70	6.6	8.01	7.40	7.00	7.5	2.3
Bicarbonate	me L^{-1}	7.23	7.0	6.79	7.00	9.50	8.80	6.75	7.7	9.90	7.94	6.83	8.2	4.4
Total N	mg L^{-1}	16.45	17.05	18.36	17.29	27.70	18.46	18.68	19.9	24.93	26.90	17.93	20.3	6.2
Phosphate	mg L^{-1}	13.45	16.51	16.42	15.46	17.4	17.5	17.0	17.4	17.0	18.4	16.8	16.7	1.3

Micronutrients and heavy metals:

The concentration of Fe, Cu and Zn are well within the limits prescribed for land disposal and may not pose any serious hazard (Table 2). The heavy metals like Cd, Cr and Pb were below detectable level in the sewage water. The heavy metal, mercury detected during monsoon and winter season (0.01 mg L^{-1}) was above the permissible limit (0.001 mg L^{-1}) as prescribed by ISI [13]. As per FAO [12], the recommended maximum concentrations of Fe, Mn, Zn, Cu, Cd, Cr, Pb for use of waste water in agriculture are 5.0, 0.2, 2.0, 0.2, 0.01, 0.1, 5.0 ppm, respectively. The higher Mn concentration (0.72 mg L^{-1}) of sewage indicates prolonged use of such sewage can cause manganese toxicity in soils.

Table 2: Micronutrient (mg L^{-1}) and heavy metals content of sewage water in the two villages

Parameter	Gabbur			Mavanur			Ground water
	Summer	Monsoon	Winter	Summer	Monsoon	Winter	
Fe	0.08	0.04	0.09	0.09	0.02	0.06	0.04
Cu	0.04	0.05	0.04	0.04	0.04	0.05	0.05
Mn	0.04	0.03	0.33	0.11	0.03	0.07	0.03
Zn	0.05	0.06	0.05	0.04	0.06	0.05	0.07
Hg	BDL	0.01	0.01	BDL	0.01	0.01	BDL
Cd	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cr	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Pb	BDL	BDL	BDL	BDL	BDL	BDL	BDL

BDL= Below detectable limit

Microbial load:

Sewage water recorded large counts of microorganisms; the order of abundance being bacteria > fungi > actionmycetes. The organic materials in the sewage water provide the needed carbon for the growth of these organisms. The annual average of bacteria, fungi and actinomycetes count ranged from 99 to 115 CFU x 10^6 ml^{-1}, 11 to 14 CFU x 10^4 ml^{-1}, 25 to 31 x 10^3 CFU ml^{-1}. among three sites (Table 3). The highest bacterial, actinomycetes, and fungal count were recorded during monsoon season which could be due to congenial climatic condition for the growth of microorganisms compared to winter and summer even though the dilution of contents of sewage water happens during the monsoon season. Higher temperature in the summer seasons perhaps arrest the growth of microorganisms present in the sewage water. However, it was interesting to note a high count of actinomycetes even during the summer in the case of UAS Dharwad campus. ***E. coli*** was present in the sewage water suggesting contamination by faecal matter.

Ground water quality:

The pH of the ground water was slightly alkaline in nature compared to sewage water (Table 1). This could be due to the presence of more organic compounds in the sewage water compared to ground water which will reduce the pH. The EC of the ground water (0.95 dS m^{-1}) was lower compared with the value of sewage water and falls under good category of irrigation water as per the classification of CSSRI, Karnal [9]. The TSS and TDS values of the ground water were 80 and 420 mg L^{-1} , respectively. The BOD (96 mg L^{-1}) and COD values (280 mg L^{-1}) were much lower than that of the sewage water and were within the permissible limits as per FAO [11] recommendation of land disposal for irrigation.. Among the anions, higher concentration of chlorides (5.0 me L^{-1}) was recorded in the ground water around the sewage irrigated areas [19] and all the other anions were well within the permissible limits as per the irrigation quality criteria. The phosphate concentration (1.3 mg L^{-1}) was much lower compared to sewage water. Among the cations, sodium was higher than the safe limits (4 me L^{-1}) prescribed for the use in irrigation whereas all other cations falls under safer limits. The micronutrients concentration was in the order Zn>Cu>Mn>Fe. The concentration of heavy metals Cd, Cr, Hg and Pb were not detected in the ground water. ***E. coli*** was not detected in the ground water suggesting that there was no contamination of sewage water.

Table 3: Microbial count in different seasons and at the three sites

Months	Bacteria (CFU x 10^6 ml^{-1})			Fungi (CFU x 10^4 ml^{-1})			Actinomycetes (CFU x $10^3 ml^{-1}$)			*E.coli* (CFU x 10^3 ml^{-1})		
	UAS D	Gabbur	Mavanur	UAS D	Gabbur	Mavanur	UASD	Gabbur	Mavanur	UAS D	Gabbur	Mavanur
Summer	86	81	80	13	9	9	37	17	16	3	4	4
Monsoon	98	137	127	18	13	14	36	41	42	4	6	6
Winter	113	127	127	12	11	11	19	18	17	6	6	8
Overall mean	**99**	**115**	**111**	**14**	**11**	**11**	**31**	**25**	**25**	**4**	**5**	**6**

CONCLUSIONS

Variations in the composition of sewage water during three seasons have been determined in this study. The pH, EC, micronutrients and heavy metals concentration (except Mn and Hg) in sewage water were within the range prescribed for irrigation purpose. The TSS, TDS, BOD, COD, sodium, phosphate, chloride and bicarbonate concentrations were above the permissible level suggesting the restriction on the use of sewage water for certain solanaceous crops and also for sprinkler irrigation. High levels of phosphates

were observed both in sites around Hubli and at UAS Dharwad campus all year round. Ground water in the vicinity of sewage irrigated area falls under good quality for irrigation.

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