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Soil health and sewage irrigation - A case study in Nagpur district

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Abstract

Characteristics of sewage effluent of the Nagpur city and properties of soils irrigated by sewage water were studied. Metal cations (Fe, Mn, Cu, Zn, Cr, Cd, Co, Ni and Pb) content of the sewage fed soils were found higher as a result of continuous application of sewage. AAAc-EDTA extractable metal contents of the soils were much more than those of DTPA-extractable values. Sewage water was found to be alkaline in reaction and contain high amount of bases. Bicarbonate and chloride contents were high and found not suitable for irrigation. Low metal cation contents of the effluent were recorded. Sewage irrigated soils were also alkaline with high exchangeable sodium percentage than soils not treated with sewage water.

Additional key words : sewage effluent, sewage fed soils, metal cations

Introduction

Water resource is becoming scarce for agriculture and also for meeting the demand of rapidly growing population and industries. At the same time the quantum of sewage water from urban population is increasing causing soil pollution and environmental hazard. Therefore, the proper treatment to sewage and use of treated sewage water in agriculture has become imperative. The sewage water contains huge amount of plant nutrients and therefore its use as a source of irrigation in agriculture is worth (Maiti *et al* 1992; Sreeramulu 1994). However, use of untreated sewage water is of public concern due to possible phyto-toxicity and/or incorporation of metal cations into the food ingredients. In view of this, it is necessary to study and monitor the use of sewage water with respect to soil-health and metal cations accumulation as a function of time and space.

Nagpur, like other industrial cities is growing faster with population and industries. The existing sewage treatment plant is not in a position to treat even 20 percent of the sewage load. Hence, many thousand hectares of agricultural land are being irrigated with untreated sewage water. The present investigation is an attempt to characterize sewage water and soils treated with it in respect of the metal cations.

Materials and methods

Measurement of sewage discharge from Nagpur city at locations Paungaon, Mahalgaon and Parshad along Nag nadi and Pili nadi (draining sewage) was carried out by the Velocity - area method using the current meter (Teledyne Gurley, Model No. 1100). Simultaneously sewage and canal irrigated soils (control), sewage and well water samples were collected from Parshad, Mahalgaon, Punapur, Leegaon, Chandmari, Bharatwada, Asoli, Beedgaon, Bhandewadi, and Tarori villages. The processed soil samples (< 2 mm) were used for determining physical and chemical properties using standard methods (Black 1965)

Metal Cations (Pb, Cd, Co, Ni, Cr, Zn, Cu, Mn, and Fe) of sewage and well waters were estimated according to Jackson (1967). Sewage sample (750 ml) was treated with

0.1 ml conc. nitric acid and evaporated to dryness. Dried samples were then treated with aqua-regia and evaporated to dryness. Adding a few drops of HNO_3 the treated samples were finally diluted to 50 ml. Metal cations contents of these solutions were determined using Inductively Coupled Plasma Spectrometer (ICP). Extractable metals of the soils were determined using DTPA extractant (Lindsay and Norvell 1978) and AAAc-EDTA (Lakanen and Ervio 1971). The AAAc-EDTA extraction solution (0.5 M CH_3COONH_4, 0.5 M CH_3COOH, 0.02 M Na_2 ETDA) was made by diluting 571 ml (100%) CH_3COOH, 373 ml (25%) NH_4OH and 74.4 g Na_2 EDTA to 10 litre with water. The pH was adjusted to 4.65 with acetic acid or ammonium hydroxide. Soil sample (25g) and extracting solution (250ml) were shaken for 1 hour. The suspension was filtered and metal contents were determined with ICP.

Results and discussion

Sewage discharge measurements indicated that the Nag nadi and Pili nadi together drain on an average 0.165 million cubic metres of waste water every day of which only 20 per cent gets primary treatment. This waste water is tapped at different locations and pumped through electric motors for irrigating vast area extending from 2 to 4 km away from the source. Almost all the agriultural crops like wheat, rice, oil seeds, sugarcane, including horticulture and floriculture are being irrigated with untreated sewage water by flooding the land, without judging the loading rate or actual requirements.

Although majority of the farmers expressed profitability of the use of the sewage water, some of the respondents reported that the yields are retarded since last few years while weeds and pests infestation became severe for some specific crops and vegetables.

The physical and chemical properties of the sewage effluent collected from different locations showed narrow variation (Table 1). The pH of the sewage effluent was alkaline (8.3 to 8.5) with conductivity ranging between 0.81 and 1.10 dS/m. It appears that the pH of the sewage water is less than critical level (Ayers and Westcott 1976; 1S:2490 1982) but the electrical conductivity (EC) tends towards medium salinity (US. EPA 1975). The effluent contains considerable amounts of basic cations. Calcium was found to be the dominant base (9.2 to 10.6 meq/L) followed by sodium (7.7 to 11.7 meq/L), magnesium (3.5 to 5.3 meq/L) and potassium (0.1 to 0.2 meq/L). It is also observed that bicarbonate (3.4 to 4.6 meq/L) and chloride (5.5 to 8.0 meq/L) contents of sewage water are so high that water becomes unsuitable for irrigation (Ayers and Westcott 1976). However, sulphate content (0.6 to 0.8 meq/L) is under permissible limit. Sodium adsorption ratio (SAR) of the sewage remains within permissible limit at present.

Properties of well water collected from different wells within the sewage fed agricultural fields showed minor variation. However, electrical conductivity and SAR values were slightly more in well water presumably due to gradual accumulation of soluble salts through ground water. This is confirmed by the presence of higher soluble salt in well water. Metal content of well water is comparatively less while Cu and Zn remained below detectable limits.

Physical and chemical properties of sewage fed and canal irrigated soils are given in table 2. The soils are clayey and moderately alkaline with pH ranging from 8.3 to 8.6. On evaluating the effect of sewage water application to soil, properties like EC, ESP, organic carbon, exchangeable sodium and potassium content of the sewage irrigated

Table 1. Properties of sewage and well water and their metal cations.

Properties	pH	EC (ds/m)	Ca	Mg	Na	K	CO3 (meq/L)	HCO3	Cl	SO4	TSS (mg/kg)	SAR
Sewage Water	8.3-8.7	0.81-1.1	9.2-10.6	3.5-5.3	7.7-11.7	0.1-0.2	3.8-4.7	6.0-7.0	3.0-4.0	0.6-0.80	500-525	3.1-4.1
Well water	7.8-8.1	0.9-1.3	1.6-4.5	3.7-3.9	8.3-12.2	0.1-0.2	0.61-3.73	3.93-4.84	4.5-5.9	0.12-0.30	545-710	3.8-4.7

Metal Cations	Cu	Fe	Zn	Mn (mg/kg)	Pb	Ni	Co	Al
Sewage Water	0.03-0.10	1.59-1.72	0.03-0.30	0.14-1.01	0.006-0.02	0.09-0.34	1.10-3.83	3.7-12.30
Well water	Trace	0.92-1.15	Trace	0.13-0.14	Trace	0.22-0.26	0.24-3.83	1.34-18.81

Table 2. Physical and chemical characteristics of the sewage and canal irrigated soils.

Location	Depth (cm)	Particle Size class: Sand	Silt	Clay	pH (1:2.5)	EC dS/m^{-1}	Org.C. (g/ kg)	$CaCO_3$ (%)	Exchangeable bases: Ca	Mg	Na	K	CEC	Base Saturation (%)	ESP
		(%)							cmol (p^+) kg^{-1}						
Parshad	0-15	8.2	33.2	58.6	8.5	0.78	1.50	4.2	25.6	8.6	1.7	1.1	38.1	97.1	4.4
Mahalgaon	0-15	6.6	31.0	62.4	8.6	0.90	0.97	3.7	28.1	10.2	2.5	1.2	43.0	97.6	5.8
Punapur	0-15	16.0	28.4	55.6	8.6	0.80	1.10	1.9	27.3	8.9	1.9	0.9	41.0	95.1	4.6
Chanmari	0-15	15.4	27.9	56.7	8.4	0.89	1.05	1.4	24.5	7.0	2.1	1.4	36.9	94.8	5.6
Bharatwada	0-15	21-0	26.0	53.0	8.6	0.79	0.81	1.3	31.0	5.2	1.6	1.2	39.6	98.4	4.0
Bidgaon	0-15	17.5	28.1	54.4	8.3	0.82	0.52	6.5	26.6	4.6	1.3	1.0	34.0	98.5	3.8
*Legaon	0-15	8.7	30.5	60.8	8.2	0.42	0.36	3.7	28.2	9.7	0.7	0.4	40.2	97.0	1.7
*Tarori	0-15	10.4	29.4	60.2	8.3	0.30	0.64	4.1	33.4	6.3	0.5	0.5	41.0	99.0	1.2

* Soils not irrrigated with sewage water

Table 3. Extractable metal contents (mg/ kg soil) of the sewage irrigated soils.

Location	DTPA-Extractable							AAAc-EDTAExtractable								
	Fe	Mn	Cu	Zn	Co	Ni	Pb	Fe	Mn	Cu	Zn	Cr	Cd	Co	Ni	Pb
Prashad	3.75	3.95	1.40	3.44	0.92	1.86	1.12	220	1012	7	8	20	0.2	20	10	23
Mahalgaon	4.40	3.36	2.46	3.26	1.08	1.16	1.56	250	1129	19	14	10	0.1	20	20	17
Punapur	2.86	3.63	1.68	3.09	0.84	1.72	1.00	150	938	6	6	10	0.2	10	8	12
Bhandewari	3.27	4.80	4.64	4.20	0.88	2.38	1.00	290	861	11	4	20	0.3	20	10	17
Bidgaon	2.06	2.18	1.9	2.97	0.86	2.34	0.64	130	734	7	5	10	0.1	10	10	12
Chanmari	2.14	3.37	1.72	2.94	0.96	2.08	0.58	260	680	9	6	18	0.2	10	15	15
Asoli	3.06	4.58	0.96	2.59	0.68	2.52	1.96	190	620	5	6	20	0.1	20	15	19
Bharatwada	2.88	2.36	1.34	3.94	0.80	2.30	1.66	170	827	8	8	21	0.2	10	20	20
Parshad*	0.66	1.69	0.44	1.95	0.60	0.38	0.20	80	410	6	3	5	tr.	4	5	11
Legaon*	1.34	1.14	0.20	1.60	0.52	0.66	0.40	90	225	3	2	6	tr.	6	9	9
Tarori*	0.60	1.78	0.70	1.75	0.52	0.24	0.24	76	360	4	2	8	tr.	3	6	5

*Soils not irrigated with sewage water

soils as compared to canal irrigated soils, it is seen that the organic carbon content of sewage fed soils were found to be slightly higher (0.52 to 1.50 g/kg) than those of canal irrigated soils (0.30 to 0.42 g/kg) and this is possibly due to incorporation of organic matter through sewage effluent. Exchangeable sodium (1.3 to 2.5 cmol (P^+)/kg, potassium (0.9 to 1.4 cmol (p^+)/kg), EC (0.82 to 0.90 dS/m) and ESP (3.8 to 5.8) of sewage applied soils were more than control substantiating the presence of more electrolyte in sewage treated soils.

Metal cations content of the soils as determined by two different methods of extraction are given in table 3. The status of metal cations was observed to be high in both the cases for sewage fed soils as compared to canal irrigated soils. Concentration of DTPA-extractable Fe, Mn, Cu, Zn, Co, Ni and Pb ranges from 2.14 to 4.40, 2.18 to 4.58, 0.96 to 4.64, 2.59 to 4.20, 0.68 to 1.08, 1.16 to 2.52 and 0.58 to 1.96 mg/kg respectively whereas Cr and Cd remained below detectable range.

AAAc-EDTA extractable metal content recorded much higher values. Exceptionally high metal concentration of AAAc-EDTA extractant was due to low pH (4.65) of the extracting medium than that of DTPA extractant (pH, 7.3).

Despite low content of metal cations in sewage effluent, the soils irrigated with sewage water received considerable amount of metal cations over the time. In view of this, it is necessary to assess periodically and monitor the sewage fed soils to avoid any adverse effect on soil health and plant growth.

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