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Research Paper

An economic analysis of effect of sewage water use for irrigation on soil properties, ground water, human health and quality of produce

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ABSTRACT : In agricultural practices, irrigation water quality is believed to affect the soil characteristics, crops production and management of water. Currently agricultural land has become a disposal site for waste water. For instance, the application of saline/sodic water results in the reduction of crop yield and deterioration of the physical/chemical properties of soil. Multistage random sampling technique was used. A total sample of 135 farmers were selected for collection of the required information for the study. The data collected were presented in tabular form to facilitate easy comparison.The soil properties and microbial population that is beneficial to the soil gets destroyed due to the deposition of chemicals, oils and acids contained in the sewage water. Farmers acknowledged the contamination of groundwater as evident through the tube well water colour and its turbidity. The incidence of heath related problems such as diarrheal diseases, cholera, malaria and typhoid were more among the farmers of sewage water villages than among the farmers of fresh water village, resulting in an increased per capita health expenditure by sewage water village farmers. The farmers in the study area recognized lower keeping quality and poor taste in case of fruits and vegetables grown under sewage water than in fresh water condition. However, on the contrarily the fruits and vegetables produced attracted a premium price for their bigger size, attractive and shining colour. Hence, there is an urgent need to plan strategies and provide thrust to the development of socially acceptable, economically viable and cost-effective waste water treatment systems to check from possible ill-effects on the environment, health and ground water.

KEY WORDS : Sewage water villages, Fresh water villages, Human health, Soil properties

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INTRODUCTION :

In agricultural practices, irrigation water quality is believed to affect the soil characteristics, crops production and management of water. Currently agricultural land has become a disposal site for waste water. For instance, the application of saline/sodic water results in the reduction of crop yield and deterioration of the physical/chemical properties of soil (Singh *et al.*, 2011). Therefore, it is of concern to the farmers if an irrigation is used, which may contain constituents capable of creating adverse effects on the soil and on agricultural produce.

Concern for public health has been the most important constraint in the use of waste water. Waste water carries a wide spectrum of pathogenic organisms posing a risk to agricultural workers, crop handlers and consumers (Blumenthal *et al*., 2001).

Waste water is used as a source of irrigation water since it serves as a source of plant nutrients. It allows farmers to reduce the use of chemical fertilizers. In this situation, waste water components can be used as an option to supply nutrients for crop growth productively. The main problem with waste water utilization for irrigation in agriculture, apart from the possibility of containing hazardous constituents, such as trace elements and organic compounds, has the risk of polluting ground water. Sewage must be treated to adapt it to agricultural uses,but treatment is also essential for safe environmental disposal, therefore, the relevant costs of waste water for agricultural reuse are just the additional costs needed for adaptation to agriculture. High levels of nitrogen in waste water may result in nitrate pollution of groundwater sources used for drinking, which could lead to adverse health effects. Keeping afore said facts in view, the present study aims at analyzing the impact of waste water use for irrigation in Dharwad district with an objective to assesseffect of sewage water use for irrigation on soil properties, ground water, human health and quality of produce.

MATERIALS AND METHODS :

The Hubli-Dharwad Municipal Corporation is the second largest corporation in Karnataka state which is partially provided with underground drainage system. About 60 million litres of sewage is being generated every day in these twin cities. The untreated sewage water is being utilized by the farmers in nearby villages along the sewage discharge canals for the past 30-35 years. This might have affected crop yields, soil health and underground water quality.

Keeping in view the objective of the study a multistage random sampling procedure was adopted for the selection of the district, talukas, villages and farmers. In the first stage, Dharwad district was selected as it serves as an agricultural representative of Karnataka state. In the second stage, Hubli taluk was selected where Hubli city's sewage waste water generated is being extensively used for irrigation purpose by farmers. In the third stage, three villages based on the sewage water used for irrigation and one village based on fresh water used for irrigation from Hublitaluk were selected for the study. These villages will purposively selected which are located along the sewage discharge channel from a very close distance to Hubli city under Hubli-Dharwad Municipal Corporation where a large volume of sewage water flows through and used for irrigation in these villages. The village Parsapur in Hublitaluk located adjacent to the above villages where fresh water is used for irrigation was selected as a control village for the purpose of comparison. The data collected from these villages served as the primary sources of data. In the fourth stage, a sample of 30 farmers who are using sewage water for irrigation in each of these villages were selected randomly for the purpose of study. Thus, a total sample of 90 farmers where sewage water is used for irrigation were selected. Another 45 sample farmers were selected randomly from control village Parsapur for the purpose of comparison who used fresh ground water for irrigation. Thus, a total of 135 farmers were selected for collection of the required information for the study. The data was collected using pre-tested and well-structured schedule. The farmers were personally interviewed. The data collected were presented in tabular form to facilitate easy comparisons. The results were summarized with the aid of statistical tools like averages, percentages *etc*. to draw valid and meaningful conclusions.

RESULTS AND DATA ANALYSIS :

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Accessibility and quality of irrigation water :

Despite the availability of water sources, it is of utmost importance that the community needs to have access to the water sources. Not only the access, but also the quality of irrigation water matters. Abundant availability and access to irrigation water with quality being poor rather proves detrimental to the soil health and its environment. The results in Table 1 showed that the proportion of respondents who opined the access to tube well irrigation water as good was marginally more in fresh water village (88.89%) than the sewage water villages (83.33%). Whereas, the accessibility of sewage water 86.67 per cent of the farmers in sewage water villages reported as good access. While, a majority of the farmers

(63.33%) responded that the quality of the sewage water they used for irrigation was poor and only 36.67 per cent farmers responded as average. This might be due to various factors such as the colour of the water, the debris that it deposits on to the farm lands, the harmful chemicals that it delivers, etc. The quality of tubewell water that they used for irrigation in sewage water villages was contaminated. This may be due to high load of nutrients in sewage water. Across the villages surveyed, water for irrigation is available throughout the year except the sewage water which is available in lesser quantity for few months due to reduced flow in sewage canal during summer. The findings of the present study were in agreement with similar findings made with respect to traces of NO_3-N (upto 2.8mg l^{-1}), Pb (upto.35mg l^{-1}) and Mn (upto 0.23mg l^{-1}) was observed in well waters near the disposal point thus, indicating initiation of ground water contamination by Yadav *et al.* (2001).

Impact of sewage water irrigation on soil properties:

It is vital to know the impact on the soil properties after many years of usage of sewage water for irrigation. A majority of the farmers (75.56%) observed that the sewage water had worsened the soil properties while, 11.11 per cent of them said there was not much effect on soil properties due to its use (Table 2). However, none of the farmers could infer any possibility of improvement in the soil properties and only 13.33 per cent felt that they were unaware of having noticed any changes in the properties of the soil. Agricultural researches have proved that persistent application of high doses of fertilizer effect the soil properties. Also the oils, chemicals, metals, Greece, hospital wastes and other acidic materials also are being carried by the sewage water through various domestic and industrial effluents of populated Hubli town. This may have changed soil structure and its properties that will affect the productivity of the soil adversely in the long

Table 1 : Accessibility and quality of irrigation water by farmers

Sr. No.	Particulars	Sewage water villages						Overall of sewage water villages (n=90)		Fresh water village (n=45)
		Katnur (n=30)		Mavanur (n=30)		Gabbur (n=30)				
		Tube well	Sewage water	Tube well	Sewage water	Tube well	Sewage water	Tube well	Sewage water	Tube well
Access to water										
1.	Good	26 (86.66)	27 (90.00)	25 (83.33)	24 (80.00)	24 (80.00)	27 (90.00)	75 (83.33)	78 (86.67)	40 (88.89)
2.	Average	4 (13.33)	3 (10.00)	5 (16.66)	3 (10.00)	6 (20.00)	6 (20.00)	15 (16.67)	12 (13.33)	5 (11.11)
Quality of water										
1.	Poor		19 (63.33)		20 (66.66)		18 (60,00)		57 (63.33)	-
2.	Average	26 (86.66)	11 (36.66)	25 (83.33)	10 (33.33)	24 (80.00)	12 (40.00)	75 (83.33)	33 (36.67)	12 (26.67)
3.	Good	4 (13.33)	-	5 (16.66)	-	6 (20,00)	-	15 (16.67)	-	33 (73.33)
Duration of water availability (months)										
		12	10	12	10	12	10	12	10	12

Note: Figures in parentheses indicate percentage to total

Table 2 : Effect of sewage water irrigation on soil properties

Sr. No.	Particulars	Sewage water villages			Overall of sewage water villages (n=90)
		Katnur (n=30)	Mavanur (n=30)	Gabbur (n=30)	
1.	Improves soil properties	0	0	0	0
2.	Worsens the soil	23 (76.66)	21 (70.00)	24 (80.00)	68 (75.56)
3.	No effect	3 (10.00)	4 (13.33)	3 (10.00)	10 (11.11)
4.	Not aware	4 (13.33)	5 (16.66)	3 (10.00)	12 (13.33)
Impact on soil					
1.	Soil hardening	16 (53.33)	15 (50.00)	18 (60.00)	49 (54.44)
2.	Soil cracks	8 (26.67)	7 (23.33)	9 (30.00)	24 (26.67)
3.	Debris accumulations	17 (56.67)	23 (76.67)	13 (43.33)	53 (58.89)

Note: Figures in parentheses indicate percentage to total

run. The microbial population that is beneficial to the soil also gets destroyed due to the deposition of chemicals, oils and acids contained in the sewage water. The population of micro-organisms such as fungi, bacteria, Azotobacter and actinomycetes was much higher in soil irrigated with sewage water and similar results was also observed in the study carried out by Ramanathan *et al*. (1997). The farmers also opined that since the sewage water irrigation as its impact on soil health, the farmers inferred that in order to minimise such negative effect are resorted to practice of irrigating fields with both fresh and sewage water.

Impact of sewage water on health status :

The direct handling and use of sewage water in raw form without any means of treatment before its use in agriculture for irrigation and also indirect influence of such practice in contamination of food cycle and water sources induced serious implications on the human health among the farmers. It could be observed from the results (Table 3) that the almost near double number of household members in sewage water villages (33.96) than the fresh water village (19.65) household members was suffered from different ailments. Majority of the family members suffered from diarrheal diseases (67.25%), cholera (13.63%), malaria (5.85%) and typhoid (13.87%) in the sewage water villages. The incidence of these diseases among the fresh water village accounted 76.81 per cent suffered from diarrheal diseases, 8.69 per cent from cholera and 14.49 per cent from typhoid. Considerably a high proportion of family members suffering from health related problems/diseases could be due to the increased mosquito menace in these villages, greater chance of contamination of drinking water sources, consistent use of sewage water for crops that could have caused a greater chance of contamination of food and could be attributed to lack of sanitation measures and unhygienic practices among the farmers in the management of sewage water for irrigation without any precautionary measures. This eventually led to higher per capita annual expenditure of Rs.1916.67 incurred for treatment of health related problems against an expenditure of only Rs.835/ person in case of control/fresh water village.

About 84.85 per cent of the households managed the finance for treatment of illness on their own in case of sewage water village, the corresponding proportion in

Table 3 : Impact of sewage water use on health status of sample farmers

Sr. No.	Particulars	Sewage water villages			Overall of sewage water villages (n=90)	Fresh water village (n=45)
		Katnur (n=30)	Mavanur (n=30)	Gabbur (n=30)		
1.	Total no. of households suffered with health related problems	10 (33.00)	12 (40.00)	11 (37.00)	33 (36.67)	12 (27.00)
2.	No. of persons suffered from health problems	60 (31.57)	54 (36.98)	65 (33.33)	179 (33.96)	69 (19.65)
Type of disease						
1.	Diarrheal diseases	41 (68.33)	38 (70.37)	41 (63.07)	120 (67.25)	53 (76.81)
2.	Cholera	9 (15.00)	9 (16.66)	6 (9.23)	24 (13.63)	6 (8.69)
3.	Malaria	-	2 (3.70)	9 (13.84)	11(6.14)	-
4.	Typhoid	10 (16.66)	6 (11.11)	9(13.84)	25(13.87)	10 (14.49)
Frequency of illness (per year)		2	2	2	2	1
1.	Annual average per capita expenditure incurred (Rs.)	1850	1785	2115	1916.67	835
Source of finance						
1.	Own	9 (90.00)	9 (75.00)	10 (90.90)	28 (84.85)	7 (58.33)
2.	Hand loan	1 (10.00)	2 (16.67)	-	3 (9.09)	4 (33.33)
3.	SHG loan	-	1 (8.33)	1 (9.09)	2 (6.06)	1 (8.33)
Distance to health facility(in km)		10	8	6	8	6

Note: Figures in parentheses indicate percentage figures
Percentage figures under farmers suffering from type of disease indicates percentage to the total number of persons suffered from health problems
Percentage figures under source of finance indicates percentage to the total number of households suffered with health related problems

case of control village was 58.33 per cent. Villages namely, Katnur and Mavanur had the primary health centre at about 8 km from the village and hence, they preferred Hubli for treatment and Gabbur which is located within the Hubli Corporation limit also preferred Hubli for medical facilities. Similar observation of village location within corporation limit was found with respect tocontrol village. These findings are in conformity with the findings of Srinivasan and Ratna (2009) who reported higher rates of morbidity exist in the waste water irrigated villages when compared to the control village.

Table 4 : Perceptions on quality of fruits and vegetable produced **(n=135)**

Sr. No.	Particulars	Quality of fruits				Quality of vegetables			
		Sewage water villages		Fresh water village		Sewage water villages		Fresh water village	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
1.	Colour								
	Dark and shining	87	64.44	9	6.67	91	67.41	10	7.41
	Light	9	6.67	87	64.44	10	7.41	91	67.41
2.	Size								
	Big	97	71.85	-	-	99	73.33	-	-
	Small to Medium	-	-	97	71.85	-	-	99	73.33
3.	Taste								
	Less tasty	97	71.85	-	-	97	71.85	-	-
	More tasty	-	-	97	71.85	-	-	97	71.85
4.	Keeping quality								
	1-2 days	93	68.89	-	-	84	62.22	7	5.19
	3-4 days	7	5.19	93	68.89	-	-	84	62.22
5.	Appearance								
	More attractive	93	68.9	13	9.63	96	71.11	5	3.70
	Less attractive	13	9.63	93	68.89	5	3.70	96	71.11
6.	Price								
	Fetch high price	93	68.89	-	-	97	71.85	-	-
	Fetch low price	-	-	93	68.89	-	-	97	71.85
7.	Mode of selling								
	Middlemen	89	65.93	89	65.93	87	64.44	87	64.44
	Directly to consumer	7	5.19	7	5.19	3	2.22	3	2.22

Table 5: Perceptions on quality of fruits and vegetable produced

Sr. No.	Particulars	Quality of fruits		Quality of vegetables	
		Sewage water	Fresh water	Sewage water	Fresh water
1.	Colour	Dark and shining	Light in colour	Dark green colour and shining	Light green colour
2.	Size	Big	Small to medium	Broader leaves	Narrow leaves
3.	Taste	Less tasty	More tasty	Less tasty	More tasty
4.	Keeping quality	1-2 days	3-4 days	Few hours/ 1-2 days	One day/ 2-3 days
5.	Appearance	Attractive	Less attractive	Attractive	Less attractive
6.	Price	Fetch high price	Fetch low price	Fetch high price	Fetch low price
7.	Mode of selling	Middlemen	Middlemen	Middlemen/ directly to consumer	Middlemen/ directly to consumer

Impact of sewage water irrigation on quality of fruits and vegetables :

When asked about farmers perceptions on the quality of fruits and vegetables grown using sewage water against fresh water (Tables 4 and 5), the farmers of both the sewage water villages and fresh water control village shared some common observations. About 64 per cent farmers revealed that the colour of fruits grown under sewage water irrigated condition was relatively darker than in case of fresh water produced fruits. Similarly, 71.85 per cent farmers reported the size of the fruits generally was bigger under sewage water irrigated condition while, it was smaller to medium in fresh water. Whereas, 68.89 per cent farmers who used sewage water for irrigation have expressed of higher prices realised in the market for their fruits and vegetables compared to the farmers of fresh water. Further, 68.89 per cent farmers revealed that the keeping quality of fruits in case of sewage water irrigated plots was lesser (1-2 days) than in case of fresh water irrigated (3-4 days) plots. In case of vegetables, 73.33 per cent farmers reported that the vegetables are characterised by broader leaves (surface area of biomass) in sewage water compared to fresh water vegetables. They also opined that fresh water output has better taste than one grown in sewage water. Majority of farmers (around 64 %) sold fruits and vegetables produce through middlemen and generally on contract basis. This difference is due to sewage water irrigation as sewage water carries heavy metals, harmful microbes, greece, lubricants, detergents, chemicals, acids, hospital wastes etc. The inferences of the present study are in agreement with those of Sharma *et al*. (2006) who recorded higher concentration of heavy metals in leafy vegetables like amaranthus, cabbage and palak than the safe limits of heavy metals in the food given by Prevention of Food Adulteration Act, 1954.

Conclusion :

The soil properties and microbial population that is beneficial to the soil gets destroyed due to the deposition of chemicals, oils and acids contained in the sewage water. Farmers acknowledged the contamination of groundwater as evident through the tube well water colour and its turbidity. The incidence of heath related problems such as diarrheal diseases, cholera, malaria and typhoid were more among the farmers of sewage water villages than among the farmers of fresh water village. This was due to continuous flow of sewage water which created unhygienic environment and offered breeding ground for the mosquitoes and snails to multiply, resulting in an increased per capita health expenditure by them. The farmers in the study area recognized lower keeping quality and poor taste in case of fruits and vegetables grown under sewage water than in fresh water condition. However, on the contrarily the fruits and vegetables produced attracted a premium price for their bigger size, attractive and shining colour.

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