GROUNDWATER QUALITY OF REGIONS SURROUNDING THE NOYYAL RIVER IN TIRUPPUR DISTRICT AND ITS IMPACT ON AGRICULTURE

ABSTRACT

Public policy is in response to public real-world problems. Its relevance is also important as well. One such policy is the control of the pollution problem in rivers. In this connection, evidence is focused here by a research study on Noyyal river pollution in Tiruppur district of Tamil Nadu state in India. The Noyyal river is one of the non-perennial rivers flowing in the eastern part of Tamil Nadu predominantly in the Tiruppur district. Its river basin, including groundwater, gradually deteriorated due to discharge of industrial effluents (pollution) over years in the river until the year 2011 after which the ZLD policy is in practice in complete stoppage of pollution. In this study, groundwater quality and its impact on the area surrounding the Noyyal river in the Avinashi and Palladam blocks of the Tirupur district after the implementation of ZLD have been evaluated. The selected block is divided into 3 regions based on the distance from the river, with 40 sample farms from each region contributing to a total of 120 samples. Based on the farmer's opinion, the study found that the quality of water was very poor in the closer region as it tastes to be poor (salty) and not suitable for use. However, in distant region, the water tastes good. The results can be proved with the results of groundwater samples in the study area with a high amount of salt contents (Ca, Mg, Na, K, Cl, etc.). The constructed water quality index is also high (>75%) in the closer region, which shows the intensity of pollution. The study concludes that pollution caused by the dyeing industries in the groundwater still exists in the study area and therefore recommends allotment of a small area of land under farm ponds to store good quality of water during rains; thereby ensuring

percolation of rainwater to improve the quality of groundwater and thus enabling the ecosystem for agricultural improvement.

Keywords: Noyyal river, Groundwater pollution, Quality, Agriculture.

INTRODUCTION

Groundwater is a very good source of drinking water and irrigation due to the purification properties of the soil. In arid and dry zones, groundwater becomes the main source of water (Fried, 1975). Today groundwater quality is deteriorated due to several industrial and man-made activities. It includes the discharge of industrial waste water, tannery waste, etc., into river basins. These wastes not only deteriorate the quality of river water, the polluted water percolates into the ground and causes groundwater pollution (Karpagam, 1991).

Groundwater contamination is the result of polluted water that infiltrates through the soil and rock and eventually hits ground water. This process can take many years and can take place at a distance from the well where contamination is found. Once the groundwater is contaminated, it is very difficult to remediate. (Geetha *et al.*, 2008). The discharge of effluents from industries is likely to affect the quality of groundwater.

Most dyeing units discharge the untreated effluent into the land, which ultimately pollutes the ground water and makes it unfit for drinking. (Noel and Rajan, 2015). The dye effluent is highly toxic in nature as it contains high suspended solid, COD, dye and chemicals along with ahigh concentration of heavy metals like Cu, Cd, Zn Ni and Pb. The dye effluent contaminates the surface and groundwater, thereby, making it unsuitable for irrigation and drinking (Mathur and Bhatnagar, 2007).

Public policy is in response to public real-world problems. Its relevance is also important. One such policy is the control of pollution problem in rivers. In this connection, evidence is focused here by a research study on Noyyal river pollution in Tiruppur district of Tamil Nadu state in India. The Noyyal river is one of the non-perennial rivers flowing in the eastern part of Tamil Nadu predominantly in the Tiruppur district. Its river basin including groundwater, gradually became deteriorated due to discharge of industrial effluents (pollution) over years in the river until 2011, after which ZLD policy is in practice in complete stoppage of pollution.

ZLD - Zero Liquid Discharge policy means, dye waste water is not to be discharged into the river, instead it has to be purified and reused by the industry itself, in order to control pollution in the Noyyal river as ordered by the High Court in the year 2011. Because of this, the pollution by industries in the river was stopped. But the effect of pollution caused prior to the year 2011 still continues even now, particularly in groundwater, which affects groundwater irrigated crops as far as agriculture (Akilan, 2016 and Babu *et al*., 2017) since groundwater pollution is very difficult to be remediated. For improving irrigation and sustainable groundwater use, this is a hindrance.

Furthermore, this poses negative impacts on agriculture and economics till now. This paved the way for us to attempt a research work that helps us to understand the current status of pollution and its effect. Specific objectives of one such study are 1) to rank the farmers' opinion on the quality of groundwater in terms of taste, appearance and use among the sample farms to develop an index of water quality and 2) to analyse the impact of water quality on agriculture in the sample farms.

DESIGN OF THE STUDY

Area selection

Avinashi and Palladam blocks of Tiruppur district is purposively selected, which is suitable to find the current status of groundwater pollution. The reason is that among the blocks through which Noyyal flows in the Tiruppur district, Avinashi and Palladam block has a larger area under groundwater irrigation.

Sampling design

The study area is divided into three different regions based on the distance of the sample farms from the Noyyal river, to find the current status of groundwater pollution and its impact on agriculture. The regions are less than 1 km from the river (closer region), 1-3 km from the river (middle region) and greater than 3 km from the river (distant region). Under each category, a quota of 40 farmers were selected randomly and hence the total sample size constitutes 120 farmers. The primary data was collected from the sample farm households with the help of well-structured, pre-tested interview schedules, bearing questions in relation to the objectives of the study.

Methodology

Water Quality Index

The water quality index is constructed using primary data collected during the survey among the farm households. Farmers were asked to rate water quality based upon the parameters like taste, appearance and use. Based on the ratings of farmers water quality using three-point scale is as follows.

$$\text{WQI} = \left(\frac{\sum_{i=1}^{3} t_i + a_i + u_i}{maximum\ score\ of\ 9}\right) x\ 100 \quad \text{------- (1)}$$

Where,

't' refers to taste – (poor – 3, medium – 2, normal – 1)

'a' refers to appearance – (bad – 3, medium – 2, good – 1)

'u' refers to use – (agriculture – 3, household and agriculture – 2, drinking, household and agriculture – 1)

In addition, six water samples were collected and given for analysis in the soil testing laboratory of the Tiruppur district and the results were tabulated. Two samples from each category (one from bore well and the other from open well) were taken for analysing the salt concentrations.

RESULTS AND DISCUSSION

Farmers' opinion on groundwater quality in the study area

The wells are mainly used for irrigation by the sample farmers, as most of the living houses are attached to farms. Therefore, in this study, parameters like taste, appearance and use of groundwater are considered to support farmers opinion and the results are tabulated below.

Table – 1 Farmers' opinion on groundwater quality in the study area

S.No	Particulars	Farm location from Noyyal river					
		<1km (Closer region)		1-3km (Middle region)		>3km (Distant region)	
		No. of farmer	Percentage	No. of farmer	Percentage	No. of farmer	Percentage
1.	**Taste**						
	Poor	33	82.50	1	2.50	-	-
	Medium	7	17.50	34	85.00	10	25.00
	Normal	-	-	5	12.50	30	75.00
	Total	40	100.00	40	100.00	40	100.00
2.	**Appearance**						
	Bad	-	-	-	-	-	-
	Medium	29	72.50	3	7.50	-	-
	Good	11	27.50	37	92.50	40	100.00
	Total	40	100.00	40	100.00	40	100.00
3.	**Use**						
	Agriculture	40	100.00	21	52.50	-	-

	Household	-	-	19	47.50	26	65.00
	Drinking	-	-	-	-	14	35.00
	Total	40	100.00	40	100.00	40	100.00

It could be seen from Table – 1, in the closer region, all parameters of groundwater quality were of poor quality. On the contrary, it was good in the regions far from the river based on farmers' opinion. Taste is one of the most important parameters of water. In the closer region, 82.50 per cent of the sample respondents rated poor (taste) indicating the poor quality. In the middle region 85.00 per cent of the sample respondents rated the taste as medium, 2.50 per cent rated as poor and 12.50 per cent as normal. However, in the distant region 75.00 per cent of the sample respondents rated taste as normal, only 25.00 per cent as medium and no poor taste was reported.

Second, using the appearance the groundwater was rated among the sample respondents. No one rated the water appearance as bad in all the three regions. According to 72.50 per cent of the sample farms, the appearance was medium and 27.50 per cent of the sample farms were as good in the closer region. In distant region all the respondents rated the appearance as good. This is because of the reason that the water is salty in nature alone, and when it comes to appearance, it is not as bad as dyeing water.

Third, based upon the usage, the groundwater was rated. 100 per cent of the respondent used ground water only for agriculture and no other use was observed in the closer region. They also stated that the groundwater is very poor in their region and unfit for agriculture, however, there is no other source for irrigation, the groundwater is being used. In middle region, groundwater is being used for agriculture (52.50 per cent) and other household purposes (47.50 per cent). In distant region, the groundwater is being used for drinking also. 35.00 per cent of the sample

respondent uses the water for drinking, household and agriculture. 65.00 per cent uses for agriculture and household purposes.

It could be concluded that the quality of water was very poor in the closer region, as it tastes to be poor (salty) and is not suitable for use. However, in distant region the water tastes good and is used for all three purposes. It could be concluded that groundwater quality based on taste, appearance and use was very poor in closer region and distant region, having good groundwater quality with few limitations.

Construction of Water Quality Index using farmers rating

Water quality index was constructed using farmers rating as three grades of water quality viz., good, medium and poor. The results were presented in the table below. Low water Quality index indicating less pollution (< 50 per cent) and high water Quality Index indicating high pollution (76 – 100 per cent).

Table – 2. Water Quality Index using farmers rating

WQI	Farm location from Noyyal river					
	<1km (Closer region)		1-3km (Middle region)		>3km (Distant region)	
	No. of farmers	Mean	No. of farmers	Mean	No. of farmers	Mean
Poor (76-100 %)	40 (100.00)	83.89	1 (2.50)	77.78	-	-
Medium (50 – 75 %)	-	-	35 (87.50)	62.54	10 (25.00)	55.56
Good (< 50 %)	-	-	4 (10.00)	44.44	30 (75.00)	39.26
Total	40 (100.00)		40 (100.00)		40 (100.00)	

Note: Figures in the parentheses indicate the percentage share to the total.

It could be inferred from Table -2, that water quality index constructed using the farmer's rating were very high for all the groundwater samples in the closer region. The average value is about 83.89 per cent in closer region and it is of poor grade. In middle region, all three grades of water quality were found. Only one sample water quality falls under a poor region with 77.78 percent of water quality index. 35 groundwater samples (87.50 per cent) fall into medium grade with an average of 62.54 per cent and 4 samples fall under good grade with an average water quality of 44.44 percent. The water samples in distant region fall under medium and good grades. 30 samples in good grade and 10 samples fall in medium grade with 39.26 per cent and 55.56 per cent of water quality index, respectively. It can also be stated that lower the value of water quality index, higher is its quality and vice versa. The results could be interpreted that farms located more than 3 km from the river had very less or no pollution, groundwater pollution had been diluted to a greater extent. Groundwater was highly polluted in closer region, and moderately polluted in the middle region, and very less or no pollution in distant region.

Test results of groundwater sample

Table –3. Salt concentrations of groundwater samples

S.No	Particulars	Farm location from Noyyal river						Permissible limit for irrigation water quality by FAO
		<1km (Closer region)		1-3km (Middle region)		>3km (Distant region)		
		Open well	Bore Well	Open well	Bore well	Open well	Bore well	
1.	**pH**	6.95	7.19	7.7	7.3	7.1	7.40	6.5 – 7.4
2.	**EC (dSm^{-1})**	10.9	7.7	2.9	2.8	1.8	1.7	3
3.	**Chloride (meq/l)**	55.2	41.2	24.0	18.0	12.0	11.1	10
4.	**Calcium (ppm)**	340	140	70	106	42	60	250

5.	**Magnesium (ppm)**	312	376.8	195.6	153.6	90	117.6	40
6.	**Sodium (ppm)**	358.8	299.46	154.56	151.57	128.34	117.3	200
7.	**Potassium (ppm)**	54.21	70.98	10.53	13.36	10.92	11.31	50
8.	**Bicarbonate (meq/l)**	0.9	0.5	0.6	0.7	0.5	0.4	8.5
9.	**Sodium Absorption Ratio (SAR)**	4.77	4.34	3.05	3.13	2.01	2.55	-
10.	**Salt type**	Magnesium chloride						NA

It could be inferred from Table – 3, that all the values were higher in the closer region and the values were drastically reduced in the distant region. EC values are very high in the closer region beyond the safe levels showing high levels of pollution in that region and they decrease in the middle region and tends to safe levels in distant regions. Salts like Calcium, Magnesium, Sodium and Chloride are higher than critical values in the closer region and tend to safer values in the distant region. However, Magnesium concentration is higher in all the three regions. But, pH, potassium and bicarbonate values lie within the safer levels. It could be concluded that most of the values in the closer region exceed general recommendations. Sheriff and Hussain, (2017) and Gowsar et al., (2019) reported similar results in the groundwater samples taken in selected places of Tiruppur district. The results of groundwater quality values obtained are compared with the FAO permissible limits for irrigation water. It was found that majority of the ionic concentrations were beyond the permissible limits prescribed by FAO. The maximum permissible limit for Electrical Conductivity (EC) was 3 dSm^{-1}, the value of EC in the closer region is greater than 7, more than two times the limit. The maximum permissible limit for Magnesium and Chloride was 40 ppm and 10 meq/l, in all the three regions the values are very high, beyond the permissible

limits since, magnesium chloride was found to be dominant in all the three regions. This can be said as evidence for the ratings given by farmers and the constructed water quality index. Since according to farmers' rating the closer region is highly affected by pollution, the same trend can be seen from the groundwater sample test results.

Impact of groundwater pollution on agriculture

Several factors have been analysed to study the impact of groundwater pollution on agricultural farms and. They are as follows.

Table – 4. Demographic pattern of the sample farms

S.No	Particulars	Farm location from Noyyal river					
		<1km (Closer region)		1-3km (Middle region)		>3km (Distant region)	
		Number	Percentage	Number	Percentage	Number	Percentage
1	**Age**						
	<40	7	17.50	12	30.00	3	7.50
	40-50	21	52.50	12	30.00	20	50.00
	>50	12	30.00	16	40.00	17	42.50
	Total	**40**	**100.00**	**40**	**100.00**	**40**	**100.00**
2	**Education**						
	Illiterate	1	2.50	6	15.00	4	10.00
	Primary	5	12.50	5	12.50	7	17.50
	Secondary	16	40.00	8	20.00	15	37.50
	Higher Secondary	11	27.50	7	17.50	2	5.00
	College	7	17.50	14	35.00	12	30.00
	Total	**40**	**100.00**	**40**	**100.00**	**40**	**100.00**
3	**Average Family size (in numbers)**						
	Male	1.45	34.36	1.62	37.33	1.35	33.75
	Female	1.47	34.84	1.52	35.03	1.40	35.00
	Children	1.30	30.80	1.20	27.64	1.25	31.25

	Total	**4.22**	**100.00**	**4.34**	**100.00**	**4.00**	**100.00**
4	**Farming experience (in years)**						
	<15	9	22.50	12	30.00	8	20.00
	15-25	15	37.50	18	45.00	24	60.00
	>25	16	40.00	10	25.00	8	20.00
	Total	**40**	**100.00**	**40**	**100.00**	**40**	**100.00**

It could be inferred from the Table - 4 that young farmers having age below 40 was low compared to other age groups in all the three regions. However, it was very low in distant region, having only 7.50 per cent (3 sample farmers) compared to middle region, having 30 per cent (12 sample farms) and the closer region, having 17.50 per cent (7 sample farms). The age group of 40-50 was found to be dominating in closer region (52.50 per cent) and distant region (50.00 per cent), whereas in middle region, the age group above 50 is high (40.00 per cent) among the sample farms.

Information on education level of the sample respondents is very important because an educated farmer would normally aware of technological, environmental and institutional changes and they follow any new strategies quickly by adopting it. Education influences the decision-making capacity of the farmers. The table showed the education level of the head of the family of the sample farms. The level of illiterate was found to be low in all the regions viz., closer region (2.50 per cent), middle region (15.00 per cent) and distant region (10.00 per cent) among the sample farms. It can also be stated that majority of the family heads had basic school education and few graduated also in all the regions.

The family size of the respondents revealed that the number of children were found to be low in all the three regions. However, the average family size was higher in middle region with average family size of 4.34 whereas in closer region it was 4.22 and it was very low in distant

region with average family size of 4.00 numbers. Only in middle region, male population was high, whereas in other two regions female population was found to be dominating.

Farming experience is another important factor that determines the decision-making capacity and success of the farm. Among the sample respondents, the numbers farmers with farming experience more than 15 years was high in all the three regions. During the field survey, most of the farmers said that farming was their forefather's occupation. In the study area, most of the farmers had very good agricultural experience. Almost 65 per cent of the farmers in each region having experience more than 15 years. It can be concluded from the above table that there exists minor variation among the sample farmers in case of farming experience and average family size, whereas in age and education variation exists. However, pollution has no impact on demographic characteristics.

Table – 5. Changes in the cropping and occupation of the study area

S.No	Particulars	Farm location from Noyyal river		
		<1km (Closer region)	**1-3km (Middle region)**	**>3km (Distant region)**
1	Predominant irrigated crop	Coconut	Coconut, Banana	Banana, Coconut
2	Predominant rainfed crop	Sorghum	Sorghum	Groundnut, Sorghum
3	Predominant occupation	Powerloom, shops	Powerloom, farming and fabrication	Farming and fabrication

It could be inferred from Table – 5, that Coconut is found to be the predominant irrigated crop in the study area followed by banana. The predominant rainfed crop is sorghum in the study area, followed by groundnut. However, banana is not cultivated in closer region, it is grown only in middle region and distant region. The reason may be due to high intensity of pollution causing

unfavourable condition for banana growth in the closer region. Similarly, groundnut is not grown in closer and middle region as rainfed crop, grown only in distant region. The reason may be due to land degradation by use of polluted water for irrigation causing unfavourable condition for groundnut cultivation in the closer and middle region. It should be noted that banana becomes the predominant irrigated crop in the distant region and same for groundnut also as rainfed crop. This shows the status of groundwater quality and land degradation in the closer region. Powerlooms, farming and fabrication are found to be the predominant occupation in the study area. However, farming is predominant in middle and distant region, this is because people in the closer region shifted towards other occupations and made it favourable for various shops in the town to dominate.

Gross income of the sample respondents

Gross income earned by the sample farms under different sources viz., On farm income, off farm income and Non-farm income are presented in the table below

Table – 6. Gross income of the sample farms (in ₹/year)

S.No	Income source	**Farm location from Noyyal river**		
		<1km (Closer region)	**1-3km (Middle region)**	**>3km (Distant region)**
1	On farm income	99433.15 (15.96)	123590.40 (19.68)	140678.33 (35.12)
2	Off farm income	17775.00 (2.85)	45225.34 (7.20)	47250.00 (11.80)
	Total farm income	**117208.15 (18.81)**	**168815.74 (26.88)**	**187928.33 (46.92)**
3	Non-farm income	505750.00 (81.19)	459200.00 (73.12)	212575.00 (53.08)
	Total gross income	**622958.15 (100.00)**	**628015.74 (100.00)**	**400503.33 (100.00)**

Note: Figures in the parentheses indicates the percentage share to the total income

It could be inferred from Table – 6, that middle region has high gross income compared to other two regions. This is because of the reason that the region has good income in farming and also in non-farm sector. However, distant region has high farm income indicating the suitability of agriculture and allied activities. In the closer region non-farm income contributes to 81.19 per cent to the total gross income whereas the sum of on-farm and off-farm is only 18.81 per cent to the total gross income. In the middle region non-farm income provides 73.12 per cent to the total gross income and the sum of on-farm and off-farm contributes to 26.88 per cent. In the distant region non-farm income is very low compared to other two regions and it is about 53.08 per cent to the total and farm income is about 46.92 per cent to the total gross income. This clearly shows that agriculture has become unfavourable in the closer region compared to other two regions because of pollution intensity. Devi et al., (2008) and Gopal et al., (2019) also reported the similar effects related to dye effluents and its impact on agriculture.

CONCLUSION

The study revealed that pollution caused by the dyeing industries in the groundwater still exists in the study area, causing deterioration of water quality, reduced crop income and crop land values in the closer region. The study also revealed that agricultural occupation was drastically reduced in the areas closer to the Noyyal river. Several farms stopped agricultural activities and switched towards other different occupations. The study area has enough water facilities to practice agriculture, but the problem lies in terms of quality. Hence, the study recommends all the farms to allot a small area of land under farm ponds accordingly to store good quality of water during rains in those ponds; thereby ensuring percolation to improve the quality of groundwater. Percolation of good quality water into the ground reduces the salt concentration of groundwater. The Public

Works Department (PWD) may start desalinating all the waterbodies in the Noyyal region and allowing them to harvest rainwater to use only for groundwater recharge purposes.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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