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Groundwater Quality of Regions Surrounding the Noyyal River in Tiruppur District and its Impact on Agriculture

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Public policy is in response to public real-world problems. Its relevance is also essential as well. One such policy is to control 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 the discharge of industrial effluents (pollution) over the years until 2011, after which the ZLD

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policy was in practice in complete stoppage of pollution. This study evaluated 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. The selected block is divided into three 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 water quality was inferior in the closer region as it tasted inadequate (salty) and unsuitable for use. However, in distant regions, the water tastes good. The results can be proved with groundwater samples in the study area with high salt contents (Ca, Mg, Na, K, Cl, etc.). The constructed water quality index is also high (>75%) in the closer region, showing the pollution intensity. 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 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.

1. INTRODUCTION

Groundwater is an excellent source of drinking water and irrigation due to the purification properties of the soil. In arid and dry zones, groundwater becomes the primary water source [1]. Today, groundwater quality has deteriorated due to several industrial and man-made activities. It includes the discharge of industrial wastewater, tannery waste, etc., into river basins. These wastes deteriorate river water quality and cause polluted water to percolate into the ground and cause groundwater pollution [2].

Groundwater contamination results from polluted water infiltrating the soil and rock and eventually reaching groundwater. This process can take many years and occur far from the well where contamination is found. Once the groundwater is contaminated, it is not straightforward to remediate [3]. The discharge of effluents from industries is likely to affect groundwater quality.

Most dyeing units discharge untreated effluent into the land, ultimately polluting the groundwater and making it unfit for drinking [4]. The dye effluent is highly toxic as it contains highly suspended solids, COD, dye, and chemicals and a high concentration of heavy metals like Cu, Cd, Zn, Ni, and Pb. The dye effluent contaminates the surface and groundwater, making it unsuitable for irrigation and drinking [5].

Public policy is in response to public real-world problems. Its relevance is also significant. One such policy is to control 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 the discharge of industrial effluents (pollution) over the years until 2011, after which ZLD policy was 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. However, the effect of pollution caused prior to the year 2011 continues even now, particularly in groundwater, which affects groundwater-irrigated crops as far as agriculture [6,7] since groundwater pollution is challenging to remediate. This is a hindrance to improving irrigation and sustainable groundwater use.

Furthermore, this poses negative impacts on agriculture and economics till now. This paved the way for us to attempt research work that helps us understand the current status of pollution and its effects. 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 analyze the impact of water quality on agriculture in the sample farms.

2. DESIGN OF THE STUDY

2.1 Area Selection

Avinashi and Palladam, blocks of Tiruppur district, are 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.

2.2 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; hence, the total sample size constituted 120 farmers. The primary data was collected from the sample farm households with the help of well-structured, pre-tested interview schedules bearing questions about the study's objectives.

3. METHODOLOGY

3.1 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 on taste, appearance, and use. Based on their ratings, water quality is rated using a three-point scale.

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

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 a bore well and the other from an open well) were taken to analyze the salt concentrations.

4. RESULTS AND DISCUSSION

4.1 Farmers' Opinion on Groundwater Quality in the Study Area

The wells are mainly used for irrigation by the sample farmers, as most living houses are attached to farms. Therefore, in this study, parameters like taste, appearance, and groundwater use support farmers' opinions, 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 can be seen from Table 1 that 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' opinions. Taste is one of the most important parameters of water. In the closer region, 82.50 percent of the sample respondents rated poor (taste), indicating poor quality. In the middle region, 85.00 percent of the sample respondents rated the taste as medium, 2.50 percent as poor, and 12.50 percent as usual. However, 75.00 percent of the sample respondents rated taste as expected in the distant region, only 25.00 percent as a medium, and no poor taste was reported.

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

Third, based on the usage, the groundwater was rated. One hundred percent of the respondents used groundwater only for agriculture; 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, and the groundwater is being used. In the middle region, groundwater is used for agriculture (52.50 percent) and other household purposes (47.50 percent). In distant regions, groundwater is also being used for drinking. 35.00 percent of the sample respondents use the water for drinking, household, and agriculture. 65.00 percent is used for agriculture and household purposes.

It could be concluded that the water quality was inferior in the closer region, as it tastes poor (salty) and is unsuitable for use. However, the water tastes good in the distant regions and is used for all three purposes. It could be concluded that groundwater quality based on taste, appearance, and use was inferior in the closer and distant regions with good groundwater quality but few limitations.

4.2 Construction of Water Quality Index using Farmers' Rating

The water quality index was constructed using farmers' ratings of three water quality grades: good, medium, and poor. The results are presented in the Table 2. A low water Quality index indicates less pollution (< 50 percent), and a high water Quality Index indicates high pollution (76 – 100 percent).

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

4.3 Test Results of Groundwater Sample

It could be inferred from Table 3 that all the values were higher in the closer region and 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 tend 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 have safer values in the distant region. However, Magnesium concentration is higher in all the three regions. However, pH, potassium, and bicarbonate values are within the safest levels. It could be concluded that most of the values in the closer region exceed general recommendations. Sheriff and Hussain [8] and Gowsar et al. [9] 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 the majority of the ionic concentrations were beyond the permissible limits prescribed by FAO. The maximum permissible limit for Electrical Conductivity (EC) was three dSm^{-1}, and the value in the closer region was greater than 7, which was more than two times the limit. The maximum permissible limit for Magnesium and Chloride was 40 ppm and ten meq/l; in all three regions, the values are very high, beyond the permissible limits since magnesium chloride was dominant in all three regions. This can be said as evidenced by the ratings given by farmers and the constructed water quality index. Since, according to farmers' ratings, the closer region is highly affected by pollution, the same trend can be seen from the groundwater sample test results.

4.4 Impact of Groundwater Pollution on Agriculture

Several factors have been analyzed to study the impact of groundwater pollution on agricultural farms.

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 of the total

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

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

Information on the education level of the sample respondents is crucial because an educated farmer would normally be aware of technological, environmental, and institutional changes, and they follow any new strategies quickly by adopting them. Education influences the decision-making capacity of the farmers. The Table 4 shows 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., the closer region (2.50 percent), middle region (15.00 percent), and distant region (10.00 percent) among the sample farms. It can also be stated that the majority of the family heads had basic school education, and few graduated in all the regions.

The family size of the respondents revealed that the number of children was found to be low in all three regions. However, the average family size was higher in the middle region, with an average family size of 4.34, whereas in the closer region, it was 4.22, and it was very low in the distant regions, with an average family size of 4.00 numbers. Only in the middle region was the male population high, whereas, in the other two regions, the female population was found to be dominating.

Farming experience is another critical factor that determines the decision-making capacity and success of the farm. Among the sample respondents, the number of farmers with a farming experience of more than 15 years was high in all three regions. During the field survey, most farmers said farming was their forefather's occupation. In the study area, most of the farmers had excellent agricultural experience.

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

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 indicate the percentage share of the total income

Almost 65 percent of the farmers in each region have more than 15 years of experience. It can be concluded from the above Table 4 that there is minor variation among the sample farmers regarding farming experience and average family size, whereas variation exists in age and education. However, pollution has no impact on demographic characteristics.

It could be inferred from Table 5 that Coconut is 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, bananas are not cultivated in the closer regions; they are grown only in the middle and distant regions. The reason may be the high intensity of pollution, which causes unfavorable conditions for banana growth in the closer region. Similarly, groundnuts are not grown in closer and middle regions as rainfed crops; they are grown only in distant regions. The reason may be land degradation caused by using polluted water for irrigation, causing unfavorable conditions for groundnut cultivation in the closer and middle regions. It should be noted that bananas have become the predominant irrigated crop in distant regions, and the same is valid for groundnuts, which are also rainfed crops. This shows the status of groundwater quality and land degradation in the closer region. Power looms, farming, and fabrication are the predominant occupations in the study area. However, farming is predominant in the middle and distant regions because people in the closer region shifted towards other occupations, which made it favorable for various shops in the town to dominate.

4.5 Gross Income of the Sample Respondents

Gross income earned by the sample farms is earned using different sources, viz., On-farm income, off-farm income, and Non-farm income are presented in the Table 6.

It could be inferred from Table 6 that the middle region has a high gross income compared to the other two regions. This is because the region has good farming and non-farm income. However, distant regions have high farm incomes, which indicates the suitability of agriculture and allied activities. In the closer region, non-farm income contributes 81.19 percent to the total gross income, whereas the sum of on-farm and off-farm is only 18.81 percent to the total gross income. In the middle region, non-farm income provides 73.12 percent of the total gross income, and the sum of on-farm and off-farm contributes 26.88 percent. In the distant region, non-farm income is meager compared to the other two regions, it is about 53.08 percent of the total, and farm income is about 46.92 percent of the total gross income. This clearly shows that agriculture has become unfavorable in the closer region compared to the other two regions because of pollution intensity. Devi et al. [10] and Gopal et al. [11] also reported similar effects related to dye effluents and their impact on agriculture.

5. 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 cropland 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 to other occupations. The study area has enough water facilities to practice agriculture, but the problem lies in quality. Hence, the study recommends that all the farms allot a small area of land under farm ponds accordingly to store good water quality during rains in those ponds, thereby ensuring percolation to improve the groundwater quality. 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 [12-14].

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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 the writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Fried JJ. Groundwater pollution. Elsevier Scientific Publishing Company, New York; 1975.
2. Karpagam M. Environmental economics: A textbook, Sterling Publishers Pvt. Ltd. New Delhi; 1991.
3. Geetha A, Palanisamy PN, Sivakumar P, Kumar PG, Sujatha M. Assessment of underground water contamination and effect of textile effluents on Noyyal River basin in and around Tiruppur Town, Tamilnadu. E-Journal of Chemistry. 2008;5(4):696-705.
4. Noel SD, Rajan MR. Impact of dyeing industry effluent on ground water quality by water quality index and correlation analysis. Research in Biotechnology. 2015;6(1):47-53.
5. Mathur N, Bhatnagar P. Mutagenicity assessment of textile dyes from Sanganer (Rajasthan). Journal of Environmental Biology. 2007;28(1):123–126.
6. Akilan ST. Textile pollution and sociological implications-a case study in the selected villages of Noyyal River belt, Tamil Nadu, International Journal of Economic and Business Review. 2016;4(2):71-84.
7. Babu A, Chinnaiyan P, Abhinaya S. Effect of dyeing and textile industry on Noyyal river water quality, Tiruppur—a case study, Int J Civ Eng Technol. 2017;8(10):1064-1071.
8. Sheriff KM, Hussain AZ. Evaluation of groundwater quality and its suitability for irrigation use on the bank of Noyyal river at Tiruppur, Tamilnadu, India. Env. Poll. Prot. 2017;2(3):100–111.
9. Gowsar SN, Devi MN, Radha M, Vishnu RKS. Characterization of groundwater quality using principal component analysis of andipalayam and neruperichel blocks of Tiruppur District. International Archive of Applied Sciences and Technology. 2019;10(2):76-83.
10. Devi TS, Ramasamy C, Gurunathan S, Menaka S. Estimation of the negative externalities of textile dyeing industry effluents on crop productivity and value of farm lands in Tamil Nadu, Indian Journal of Agricultural Economics. 2008;63(3):1-9.
11. Gopal AV, Arun OS, Gobinath R, Saranydevi D. Experimental studies on the assessment of river water quality: A case study on Noyyal River Tirupur, Journal of Water Pollution & Purification Research. 2019;1(2):19-23.
12. Ali MH, MH, Zaman MA, Islam P, Biswas NN, Karim, and Kader MA. Quality assessment of groundwater of barind

area, Bangladesh Using Integrated Hydrochemical Method. Asian Journal of Advances in Agricultural Research2021;16(4):18-27. Availabe:https://doi.org/10.9734/ajaar/2021/v16i430181.

13. Abdelwahed, Samer Mohamed, Mohamed Ebrahim Hassan Farag, and Mohamed Ahmed Youssef. Effect of magnetic strength of the water salinity treatment devices on salt accumulation in the root zoon and Its impact on growth and productivity of olive trees. Asian Journal of Agricultural and Horticultural Research2024;11(2):117-31. Availabe:https://doi.org/10.9734/ajahr/2024/v11i2319

14. Lapworth DJ, Boving TB, Kreamer DK, Kebede S, Smedley PL. Groundwater quality: Global threats, opportunities and realising the potential of groundwater. Science of the Total Environment. 2022 Mar 10;811:152471.

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