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

Commented [M1]: The impact on the agriculture is not measurable by the methods used in this study.

ABSTRACT

Public~~A public~~ policy is in response to public real-world problems.~~problem.~~ Its relevance is also important.~~important as well.~~ One such policy is the~~is~~ control of the~~of~~ pollution problem in rivers. In this connection,~~connection, an~~ evidence is focused here by a research study on~~regarding~~ Noyyal River Pollution~~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~~in~~ Tiruppur district. Its river basin,~~basin~~ including groundwater, gradually~~gradually became~~ deteriorated due to discharge of industrial effluents (pollution) over years in the river until~~till~~ the year 2011 after which the~~which~~ ZLD policy is in~~under~~ practice in complete stoppage of pollution. In this study,~~study the~~ groundwater quality and its impact on the area surrounding the Noyyal River~~river~~ in the~~in~~ Avinashi and Palladam block of the~~of~~ Tirupur district after the~~after~~ implementation of ZLD have~~has~~ 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~~total~~ 120 samples. Based on the farmer's opinion,~~farmers opinion~~ the study found that the quality of water was very poor in the closer region as it tastes~~tastes to be~~ poor (salty) and not suitable~~unfit~~ for use. However, in a~~in~~ distant region,~~region~~ the water tastes good. The results can be proved with the results of groundwater samples in the study area with a~~with~~ high amount of salt contents (Ca, Mg, Na, K, Cl, etc.).~~etc.,).~~ The constructed~~Constructed~~ water quality index is also high (<75%) in the nearby region, which shows~~closer region showing~~ the high intensity of pollution.~~pollution intensity.~~ The study concludes that pollution caused by

the dyeing industries in the groundwater still exists in the study area and therefore~~thus~~ recommends allotment of~~to allot~~ 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~~thereby~~ enabling the ecosystem to improve~~for~~ agricultural improvement.

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Keywords: Noyyal River, Groundwater Pollution, Quality, Agriculture.~~river, groundwater pollution, quality, agriculture.~~

INTRODUCTION

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

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

Most~~Most of the~~ dyeing units discharge the untreated effluent into the land,~~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,~~dye~~ and chemicals along with a~~with~~ high concentration of heavy metals like Cu, Cd, Zn Ni,~~Ni~~ and Pb. The dye effluent contaminates the surface and groundwater,~~ground water, thereby,~~ making it unsuitable~~unfit~~ for irrigation and drinking (Mathur and Bhatnagar, 2007).

Public~~A public~~ policy is in response to public real-world problems.~~problem.~~ Its relevance is also important.~~important as well.~~ One such policy is the~~is~~ control of the~~of~~ pollution problem in rivers. In this connection,~~connection, an~~ evidence is focused here by a research study on~~regarding~~ 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~~in~~ Tiruppur district. Its river basin,~~basin~~ including groundwater,~~Groundwater,~~ gradually became deteriorated due to discharge of industrial effluents (pollution) over years in the river until~~till the year~~ 2011, after which ZLD policy is in~~under~~ practice in complete stoppage of pollution.

ZLD - Zero Liquid Discharge policy means that dyed~~means, no dyeing~~ waste water is not~~is~~ to be discharged into the river,~~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~~in the year~~ 2011. Due to~~Because of~~ this,~~this, the~~ pollution by industries in the river was stopped. But~~But,~~ the effect of pollution caused before~~prior to the year~~ 2011 still continues even now,~~now~~ particularly in groundwater,~~groundwater~~ which affects groundwater irrigated crops as far as~~for~~ agriculture (Akilan, 2016 and Babu *et al*., 2017), since~~2017) is concerned, as~~ groundwater pollution is very

difficult toto be remediated. For improvingimprovement of the irrigation and sustainable groundwater use, this is a hindrance.

Furthermore,Also, this has hadposes negative impacts onin agriculture and economics till now. This paved thea way for usway to attempt a research work thatwork, which helps us to understandknow the current status of pollution and its effect. Specific objectives of one such study areare, 1) toTo rank the farmers'farmers opinion onregarding the quality of groundwater in terms of taste, appearance,appearance and use among the sample farms to develop an index offor water quality and 2) to analyzeTo analyse the impact of water quality on agriculture in the sample farms.

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DESIGN OF THE STUDY

Description of the study area

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.....

Area selection

The AvinashiAvinashi and Palladam blocks inof Tiruppur district are purportedlyis purposively selected, which is suitable to find the currentpresent status of groundwater pollution. The reason is that among the blocks through which Noyyal flows in thein Tiruppur district, thedistrict, Avinashi and Palladam blocks haveblock has a larger area under groundwater irrigation.

Sampling design

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The study area is divided into three different regions based on the distance of the sample farms from the Noyyal river,river, in order to find the current statepresent status of groundwater

pollution and its impact on agriculture. The regions are lesslesser 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 waswere selected randomly selected,randomly and hence the total sample size constitutes 120 farmers. The primary data werewas 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 indexWater Quality Index is constructed usingusing the primary data collected during the survey amongamong the farm households. FarmersThe farmers were asked to rate water quality based upon the parameters like taste, appearance and use. Based on the water qualitythe ratings of farmersfarmers water quality using a three-point3 point scale as follows.

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

whereWhere,

't' refers torefers taste – (poor(Poor – 3, mediumMedium – 2, normalNormal – 1)

'a' refers torefers appearance - (bad - (Bad – 3, medium -Medium – 2, good -Good – 1)

'u' refers torefers 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 theof Tiruppur district and the results were tabulated. Two samples offrom each

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category (one from the~~from~~ bore well and the other from the~~from~~ open well) were~~was~~ taken for analysis.

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Commented [M9]: There is not statistical analysis done and methods used both in materials and methods and in the result section. Regression analysis or other multivariate analysis is necessary, at the very least, to accomplish it.
The materials and methods did not provide the laboratory protocol that was utilized to analyze the physicochemical characteristics.
In my opinion, a better indicator for agriculture would have been to concentrate on nutrients like nitrate, nitrate, total phosphate, and total ammonia.

RESULTS AND DISCUSSION

Farmers'~~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~~Hence the~~ parameters such as~~like~~ taste, appearance and use of groundwater are considered to support farmer opinion,~~in this study for farmers opinion~~ and the results are tabulated below.~~below~~

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

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

Third,~~Thirdly,~~ based on~~upon the~~ usage, the groundwater was rated. 100 percent~~per cent~~ of the respondents~~respondent~~ used groundwater~~ground water~~ only for agriculture and no other use was observed~~noticed~~ in the region~~the~~ closer to it.~~region.~~ They also stated that~~that the~~ groundwater is very poor in their region and unsuitable~~unfit~~ for agriculture; however,~~agriculture, however~~ there is no other source for irrigation,~~irrigation, the~~ groundwater is being used. In the~~In~~

middle region,~~region~~ groundwater is~~is being~~ used for agriculture (52.5%)~~(52.50 per cent)~~ and other household purposes (47.5%).~~(47.50 per cent).~~ In distant regions,~~region the~~ groundwater is also~~is~~ being used for drinking.~~drinking also.~~ 35.00 per cent of the sample respondent uses the water for drinking, household,~~household~~ and agriculture. 65.00 per cent uses for agriculture and household purposes.

It could be concluded that the quality of the~~of~~ water was very poor in the northern region,~~closer region~~ as it tastes~~tastes to be~~ poor (salty) and is not suitable~~unfit~~ for use. However, in the~~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 the~~in~~ closer region and the~~and~~ distant region,~~region~~ having good groundwater quality with few limitations.

Construction of Water Quality Index Using Farmers Rating~~using farmers rating~~

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The Water~~Water~~ Quality Index~~index~~ was constructed using farmers' ratings~~farmers rating~~ as three grades of water quality viz., good, medium and poor. The results are~~were~~ presented in the table below. Low water quality~~Quality~~ index indicating less pollution (< 50 per cent) and high water quality index~~Quality Index~~ indicating high pollution (76 - 100%).~~ 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: The figures~~Figures~~ in~~in the~~ parentheses indicate the percentage share to the total.

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

Groundwater Sample Test~~Test~~ Results~~results of groundwater sample~~

Table –3. Groundwater Sample Test~~Test~~ results of groundwater sample

Commented [M11]: This result should be supported with the statistical tests to see the significance of the differences among the water sources and study sites

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~~ – 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,~~levels~~ showing high levels of pollution in that region,~~region~~ and they decrease~~it decreases~~ in the middle region and tend~~tends~~ to safe levels in distant regions. Salts like calcium, magnesium, sodium,~~Calcium, Magnesium, Sodium~~ and chloride~~Chloride~~ are higher than critical values in the closer region and tend~~tending~~ to safer values in the distant region. However, the magnesium~~Magnesium~~ concentration is higher in all~~all the~~ three regions. But~~But,~~ pH, potassium,~~potassium~~ and bicarbonate~~Bicarbonate~~ values lie within the safer levels.

It could be concluded that most of the values in the near-regularcloser region exceed theexceed general recommendations. Sheriff and Hussain, (2017) and Gowsar et al.al., (2019) reported similar results inin the groundwater samples taken in selected places inof Tiruppur district. The results of theof groundwater quality values obtained are compared with the FAO permissible limits for irrigation water. It was found that thethat majority of the ionic concentrations were beyond the permittedpermissible limits prescribed by FAO. The maximumMaximum permissible limit for Electrical Conductivity (EC) was 3 dSm^{-1}, the value of EC in the closer region is greater than 7, more than twicetwo times the limit. The maximum permissible limit for magnesiumMagnesium and chlorideChloride was 40 ppm and 10 meq/l, in allall the three regions the values are very high, beyond the permissible limits sincesince, magnesium chloride was found to be dominant in allall 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' ratings.farmers rating the closestcloser region is highly affected by pollution, the same trend can be seen in the results offrom the groundwater sample test.test results.

Impact of Groundwater Pollutiongroundwater pollution on Agriculturagriculture

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

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Commented [D13]: This should be at the beginning

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	>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 fromfrom the Table Table – 4 that the age ofthat young farmersfarmers having age below 40 was low compared to other age groups inin all the three regions. However, it was very low in thein distant region,region having only 7.50 per cent (3 sample farmers) compared to theto middle region,region having 30%30 per cent (12 sample farms) and theand closer region,region having 17.50 per cent (7 sample farms). The age group of 40-50 was found to be dominating in thein closer region (52.50%)(52.50 per cent) and distant region (50.00%), while(50.00 per cent), whereas in thein middle region theregion age group above 50 is high (40.00%)(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 benormally aware of technological, environmental,environmental and institutional changes and wouldthey follow any new strategies quickly by adopting it. Education influences the decision-making capacity ofof the farmers. The table showed the education level of the head ofthe familyfamily heads of the sample farms. The level of illiteracyilliterate was found to be low in all the regions viz., closer region (2.50 per cent), middle region (15.00%)(15.00 per cent) and distant region (10.00%)(10.00 per cent) among the sample farms. It can also be stated that thethat majority of the head of thethe familyfamily heads had ahad basic school education and few alsofew graduatedgraduated also in allall the regions.

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

The farmFarming experience is another important factor that determinesdetermining thethe decision-making capacity for decision makingcapacity and theand success of the farm. Among the sample respondents, the number ofrespondents, farmers with farming experience more than 15 years waswas to be high in allall the three regions. During the field survey, mostmost of the farmers said that farming was their forefather's occupation. In the study area, mostmajority of the farmers had very good agricultural experience.were well experienced in farming. Almost 65%65 per cent ofof the farmers in each region havehaving experience more

than 15 years. It can be concluded from the above table that there exists minor variation among the sample farmers in the~~in~~ case of farming experience and average family size, whereas in age and education there exists variation.~~variation exists.~~ However, pollution has no impact on demographic characteristics.~~characters.~~

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

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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~~Table –~~ 55 ~~,~~ that coconut~~Coconut~~ is~~is found to be~~ the predominant irrigated crop in the study area followed by bananas.~~Banana.~~ The predominant rain~~rainfed~~ crop is sorghum in the study area,~~area~~ followed by groundnut. However, bananas are~~Banana is~~ not grown in the closest~~closer~~ region, they are~~it is~~ grown only in the~~in~~ middle region and the~~and~~ distant region. The reason may be due to the~~to~~ high intensity of pollution that causes a negative~~causing unfavourable~~ condition for banana growth in the northern~~closer~~ region. Similarly, groundnut is not grown in the~~in~~ closer and middle region as a~~as~~ rainfed crop, grown only in the~~in~~ distant region. The reason may be due to land degradation due to the~~by~~ use of polluted water for irrigation causing unfavourable conditions~~condition~~ for groundnut cultivation in the middle~~closer~~ and near~~middle~~ region. It should be noted that banana becomes the predominant irrigated crop in the distant region and the~~and~~ same applies to groundnuts~~for groundnut also~~ as it is a~~as~~ rainfed crop. This shows the state~~status~~ of groundwater quality and

land degradation in the surroundingcloser region. Powerlooms, farming,farming and fabrication are found to be the predominant occupation in the study area. However, farming is predominant in thein middle and distant region;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-farmOn farm income, off-farm income,off farm income and Non-farm income are presented in the table below.below

Table – 6. Gross income of the sample farms (in / year)₹/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 inin the parentheses indicateindicates the percentage share to the total income.income

It could be inferred from Table -6 6, that thethat middle region has ahas high gross income compared to theto other two regions. This is becausebecause of the reason that the region has good income in farming and also in thein non-farm sector. However, theHowever, distant region has high farm income,income indicating the suitability of agriculture and relatedallied

activities. In the closer region, nonfarm~~region non-farm~~ income contributes to 81.99%~~81.19 per cent~~ to the total gross income,~~income~~ whereas the sum of on-farm and off-farm is only 18.81%~~18.81 per cent~~ to the total gross income. In the middle region, nonfarm~~region non-farm~~ income provides 73.32%~~73.12 per cent~~ to the total gross income and the sum of on-farm and off-farm contributes to 26.48%.~~26.88 per cent.~~ In the distant region,~~region~~ non-farm income is very low compared to other two regions,~~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 the~~to~~ other two regions due to the intensity~~because~~ of the pollution.~~pollution intensity.~~ Devi et al.~~al.,~~ (2008) and Gopal et al.~~al.,~~ (2019) also reported~~reported the~~ similar effects related to dye effluents and their~~its~~ impact on agriculture.

CONCLUSION

Commented [M16]: Most of your conclusion statements are not based on your results

The study revealed that pollution caused by the dyeing industries in~~in the~~ groundwater still exists in the study area, causing deterioration of water quality, reduced crop income,~~income~~ and crop land values in the region closer.~~closer region.~~ The study also revealed that agricultural occupation was drastically reduced in the areas closer to the Noyyal River.~~river.~~ Several farms stopped agricultural activities and switched to~~shifted towards~~ other different occupations. The~~It is also found that the~~ study area also~~area~~ has enough water facilities to practice agriculture,~~for practicing agriculture~~ but the problem lies in terms of quality. The study also recommends that~~recommends~~ all~~all the~~ farms allocate~~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. The Public Works Department (PWD) can

beginmay start desalinating allall the waterbodies in the Noyyal region and allowing them to harvest rainwater to useutilize only for groundwater recharge purposes.

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