SOCIO-ECONOMIC ASSESSMENT OF GROUNDWATER POLLUTION ON AGRICULTURE
With Special Reference to Selected Villages in Tirupur District

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ABSTRACT

The industrial revolution which brought huge comforts to mankind has also been responsible for manifold miseries and disadvantages. The process of industrialization, which aims at the mass-production of goods of better quality, fulfils the human needs. The effects of improper discharge of effluents into river basins are being dramatically demonstrated in most developing countries and India has not been left out. Quality of groundwater is deteriorating and its effects are becoming evident daily, some gradual and some sudden. This is threatening human livelihood as a whole. The study assessed about groundwater deterioration in four villages in the downstream of Tirupur due to dyeing and bleaching units effluents which is released in River Noyyal. The effluents from the textile industries which are released into River Noyyal affect the groundwater, land, human and livestock resources. The farmers are the sample group targeted for the study.

The objectives of the study are; first, to assess the current status of households in relation to the environmental conditions in the selected villages in Tirupur District and the second, to assess the effects of groundwater pollution on agriculture. The methodology used in this study is descriptive and analytical. This includes: frequency distribution, cross tabulations and chart analysis. The result shows that the farmers' groundwater has been affected by discharge of effluents in the river basins which affects the nearby land. Nearly one-half of the respondents' stated that the water available was not suitable for agriculture. Seventy-five percent of the farmers inferred that, their water contains more turbidity and salinity. Since, the farmers shifted their cropping pattern to the extent of water availability and some are changes their occupation from agriculture to non-farm activities. It is recommended that farmers be given training on mixed and co-operative farming methods to evacuate from groundwater pollution problems.

Key words: Effluents, Agriculture, Groundwater Pollution, Water Quality

Introduction

Water is one of the most important natural resources and is essential to all structures of life. Water bodies located in the system of the environment are facing various changes due to human activities. Groundwater and surface water is being contaminated by several sources. The careless disposal of industrial effluents and other wastes may contribute greatly to the poor quality of water. The availability and quality of water always have played an important role in determining the quality of life. Quality of water is closely linked to water use and to the state of economic development (Walakaria, 2011). Water is also a vital resource for agriculture, manufacturing, transportation and many other human activities. Despite its importance, water is the most poorly managed resource in the world. (Phiri et al, 2005).

There is growing concern about the quality of water available for irrigation due to the increased implications of wastewater use for the hydrology of many river basins. Rapidly increasing urban pollution and industries lead to increased wastewater and ways of contamination were becoming more complex. It includes industrial waste, such as heavy metals, acids, and derivatives of plastics and organic components.

In India, as elsewhere in the world, the urban and other big cities are affected by this problem. Because of such rapid industrialization, most of the available water in the country is polluted. Tanneries and textile dyeing and finishing are two subsectors within these growing industries that contribute to environmental degradation, more exclusively to water pollution. Industry related water pollution is particularly intense during the dry seasons.

The major cause of water pollution is the letting out of untreated industrial effluents into rivers and open spaces around industries. For example, textile units, tanneries, paper industries, sugar industries, dyeing industries along with other industries let out their effluents into the closest rivers or allow them to languish on land. These effluents dribble through the soil and pollute the groundwater.

Farmers have been using wastewater for irrigation to compensate for scarce or costly freshwater resources. Roughly, 10 per cent of the world's wastewater is currently being used for irrigation. In developing countries, like China and India, an estimated eighty per cent of wastewater may be needed for irrigation (Jaramillo, 2017). It is estimated that farmers irrigate nearly 20 million hectares using partially diluted or undiluted wastewater, a practice that sustains the livelihoods of millions of poor people in Asia, Latin America, the Middle East and parts of Africa. In fact, in many countries, there are more hectares under informal irrigation with polluted urban stream/drain water than formal irrigation schemes (Naidoo, 2014).

Statement of the Problem

Industrial disposal of effluents on land and the subsequent pollution of groundwater and soil of surrounding farmlands in this particular study area is relatively new area of research. The socio-economic effects of industrial effluents irrigation have not been studied as extensively as domestic waste based on irrigation practice at least for a country like India.

Many dyeing industries are operating in Tirupur Taluk. A large quantity (about 42,050 kiloliters) of wastewater or effluent is discharged from the dyeing units to the river streams during the processes. Effluents of these bleaching and dyeing units released into agricultural lands also deteriorate the soil because of their physical and chemical properties. The quality of groundwater in shallow open wells surrounding the industrial locations has deteriorated and the application of polluted groundwater for irrigation has resulted in changing the water quality and more salt content in soils. It started reducing the production of agricultural crops. Though Tirupur Taluk was a major cotton cultivating area, due to a discharge of effluents, the farmers have switched over to alternate crops like Sorghum, Maize and other commercial crops in the Noyyal river basin and substituted their irrigation source from shallow open-wells to deep bore-wells and/or purchasing water from vendors to equalize their scarcity of water, the impact of groundwater pollution on livelihoods in this area was maximizing. Farmers in the adjoining areas have found the groundwater unsuitable for irrigation. The continuous application of polluted groundwater for irrigation has also resulted in rising salinity in soil. On this background, the researcher felt it necessary to make a socio-economic assessment of the ground water pollution on agriculture in selected villages along the Noyyal river basin.

Objectives of the Study

The objectives of the study are

1. To study the socio-economic characteristics of the farm households in selected villages in Tirupur District.
2. To assess the external effects of groundwater pollution on the water resources, cropland, and changes in water quality.

Methodology: Brief Description of Study Area:-

Noyyal river basin includes four districts viz., Coimbatore, Tirupur, Erode and Karur. There are about hundred villages situated on both sides - north and south of the banks of river Noyyal. The total river basin can be divided into three divisions for the purpose of our study. Velliangiri hills to Tirupur (Upstream), Tirupur downstream to Orathupalayam dam and downstream of Orathupalayam dam to the end of the river at Noyyal village where it joins river Cauvery.

Out of these three divisions, division II is taken and this is considered as the study area for the basic environmental issues. In these areas, bleaching and dyeing units are more and agriculture was affected to a great extent. The respondents in this area started moving for their livelihood to various industries situated nearby. So, the present study selected few villages in downstream of Tirupur districts.

Research Design

This study is descriptive and exploratory in nature. With the descriptive design, the researcher plans to gain more information about a phenomenon within a particular field of study by examining the characteristics of a specific single population. Exploratory study would provide an in-depth exploration of a single process.

Sampling Design

In each village around 15 per cent of the households were selected for the study through purposive random sampling. Using a purposive random technique, the farmers who were affected by groundwater pollution and willing to provide the necessary data for the study were selected. The total size of the sample was 134 from the total of 1722 farmers.

Methods of Data Collection

Primary data was collected from the sample farm households with the help of well-structured interview schedule which is based on the objectives of the study and an interview schedule was managed to the respondents. The schedule contained two parts of questions related to the socio-economic characteristics of the farmers and agricultural activities.

Tools of Analysis

Initially, all collected data were carefully entered in Excel and exported to SPSS/windows version 16.0. The statistical methods like frequency distribution, cross tabulations and charts were used.

Review of Literature

A few studies relating to topic under discussion is presented below.

Prabhakaran (1995) revealed that the effluent of textile industries had affected the groundwater quality through infiltration by way of increased Electronic Conductivity (EC) Sodium Adoption Ratio, SAR and RSC. The influence of such untreated effluents on underground water was also reported by Muthusamy et al (1995) also showed that the discharging of chemicals in Tirupur turned the groundwater as well as the surface water unsuitable for irrigation and domestic applications.

Sekar (2003) in a study in Tamilnadu found that the pollution of groundwater is high due to industrial effluent. Pollution on water resources had resulted in some external effects on land quality, land value, crop yield, loss of manpower, employment etc. The externalities caused by the changes in the qualities of water resources due to mismanagement and misuse included the common health disorders. Farmers had incurred a total amount of Rs. 518 per annum per household consulting fees for medical doctors and cost of medicine and loss in time and management, reduction in animal population, poor health status, reduction in milk yield was the external effects on animals due to degradation of groundwater. Land selling, diversion of farmlands for non-agricultural activities, labour movements towards the non-farm sector and poor economic status where the consequences of pollution externalities observed.

Udayasooriyan and Prabu (2003) conducted a study to assess the impact of continuous effluent discharge of paper industry on irrigation of soil and on groundwater in the Cauvery river basin. The study had found that the paper mill effluent had increased the soil pH, electrical conductivity in irrigated soils. The potential salinity of the groundwater in the effluent irrigated field had increased three times over control limit and the values crossed the safer limits in many places indicating that the groundwater was polluted with chlorides and sulphates.

Balakrishnan *et al.* (2008) assessed the "Impact of Dyeing Industrial Effluents on the Groundwater Quality in the Kancheepuram (India)" by investigating the effects of dyeing industrial effluents on the quality of groundwater in and around the Kancheepuram town with reference to drinking and irrigation purposes. Twenty groundwater samples were collected from various parts of the dyeing industrial regions and samples were analyzed with standard analytic methods. The concentrations of TDS, Chloride Hardness, Sulphate, Nitrate, Iron and Lead were found to be higher and exceeded the permissible limits of BIS and WHO standard. The User Specific Water Quality Indices (USWQI) of each groundwater samples were evaluated for both purposes. The USWQI of the groundwater samples varied from 85 to 30 for drinking purpose and 89 to 50 for irrigation purpose. The results show that the groundwater quality in the present study area can be categorized under 'good' for irrigation and 'fair' for drinking water.

Results and Discussion: Socio-Economic background of the Respondents

The social and economic characteristics considered relevant for the study are selected based on the exploration of the available literature.

Table 1 - Average Social Background of the Respondents

Description	Kodumanal	Kathanganni	Nallur	Anaipalayam	Total	Std. Dev
Number of samples	32	38	32	32	134	-
Average age	46	46	48	46	46	8.912
Average years of Education	10	6	8	8	8	5.030
Average size of Family	4	3	4	3	3	1.080
Average area of cultivation	2	2	2	3	2	1.641
Average years of nativity	40	42	36	40	40	19.787

Source: Primary survey

The average age of the respondents in the study villages is more than 40 years, which shows that the farmers have strong experience in agriculture and environmental conditions of the area. The average age of the respondents (breadwinner of the family) is 46 years. The farmers' average years of education are eight years only. Even though, the respondents have limited exposure in formal education, but they are technically innovated and updated farmers in cultivation. The family size is three, in that most of the members are economically active in earning income. The female members also participated in on-farm activities, livestock rearing etc. Most of the farmers in the study area were small and medium size landholders but the average land under cultivation was only two acres.

Average Income of the Respondents

The table below indicates the monthly and yearly average income earned by the respondents.

Table 2 - Average Income and Expenditure of the Respondents

Description	Kodumanal	Kathanganni	Nallur	Anaipalayam	Total	Std. Dev
Number of samples	32	38	32	32	134	
Average income of the family (monthly)	Rs.16578	Rs.15026	Rs.15718	Rs.14400	Rs.15350	9663
Average expenditure of the family (monthly)	Rs.13115	Rs.13342	Rs.11281	12484	Rs.12591	7411
Average income from agriculture (Yearly)	Rs.24092	Rs.16930	Rs.23739	Rs.32638	Rs.23014	26291
Average income from alternative occupation (monthly)	Rs.8115	Rs.8871	Rs.8270	Rs.13812	Rs.9646	9608

Source: Primary Survey

Apart from social activities, total monthly income of the households contributes only 15 to 20 per cent. The results from the study shows that expenditure of the family (Rs.12591 is lower than the average monthly income of the households. It is assumed that, the remaining portion of amount was saved by the respondents. The total income from agriculture and secondary occupation differs significantly for the respondents. The yearly agriculture income is less than the secondary occupation due to environmental pollution and seasonal variations leading to deterioration in agriculture.

Water Availability for Agriculture

Table 3 shows the suitability of water availability for agriculture.

Table 3 – Suitability of Water Availability for Agriculture

Water Availability	Kodumanal	Kathanganni	Nallur	Anaipalayam	Total
Good	3 (9)	4 (10)	1 (3)	10 (31)	18(13)
Fair	11(34)	16 (42)	17 (53)	9 (28)	53(40)
Bad	18 (56)	18 (47)	14(44)	13 (41)	63(47)
Total	**32(24)**	**38(28)**	**32(24)**	**32(24)**	**134(100)**

Source: Primary Survey

It is observed from the table and chart that, on an average one-half and 56 per cent in Kodumanal, 47 per cent in Kathanganni, 44 per cent in Nallur and 41 per cent in Anaipalayam reported that availability of water was not suitable for cultivation. On an average, two-fifth of the respondents said availability of water was fair and 13 per cent felt it was good for agriculture and that was mainly in Anaipalayam village. Nearly one-half of the respondents stated that the water available for cultivation was not enough.

Water Quality for Agriculture

The table shows the water quality for agricultural purpose.

Table 4 - Water Quality for Agriculture

Water quality	Kodumanal	Kathanganni	Nallur	Anaipalayam	Total
Good	7 (22)	5(15)	2 (6)	5(15)	19(14)
Fair	12(37)	16 (42)	14 (44)	11(34)	53(40)
Bad	13 (41)	17 (45)	16 (50)	16(50)	62(46)
Total	**32(24)**	**38(28)**	**32(24)**	**32(24)**	**134 (100)**

Source: Primary Survey

One-half of the respondents in Nallur and Anaipalayam, 45 per cent in Kathanganni and 41 per cent in Kodumanal said that the water quality was very bad to take up agricultural activities. The water quality was felt fair by two-fifth while only 14 per cent opined that the quality of water for agriculture was good.

Characteristics of Changes in Water Quality

The characteristics of changes in the quality of water which made it bad were analysed and the same is presented in the table below.

Table 5 – Characteristics of Changes in Water Quality

Kind of Change	Kodumanal	Kathanganni	Nallur	Anaipalayam	Total
Turbidity	15(47)	18 (47)	13(41)	7 (22)	53(39)
Taste and Odour	3(9)	9(24)	5(16)	9(28)	17(13)
Colour	2(6)	2 (5)	1(3)	10 (31)	15(11)
Salinity	12(37)	9(24)	13(41)	6(19)	50(37)
Total	**32(24)**	**38(28)**	**32(24)**	**32(24)**	**134 (100)**

Source: Primary survey

Turbidity was high in Kodumanal, Kathanganni and Nallur villages; salinity was reportedly high in Kodumanal and Nallur; taste and odour of the water available in was affected in Kathanganni, Nallur and Anaipalayam while the change in water colour was seen more in Anaiplayam village.

Result of Water Quality in Selected Villages

A total number of nine water samples, three samples from each sample village were collected and analysed using nine parameters at the Department of Environmental Science, Tamil Nadu Agricultural University, Coimbatore.

Table 6 - Test Results of Water Sample

Parameters	Kodumanal			Kathanganni			Nallur			Anaipalayam		
	Site I	Site II	Site III	Site I	Site II	Site III	Site I	Site II	Site III	Site I	Site II	Site III
pH (6.5 -8.5)	8.30	8.28	7.71	7.81	7.91	8.59	8.70	7.22	7.27	9.42	8.02	8.91
EC (5-15 dS m^{-1})	6.09	7.15	4.13	4.11	4.12	1.35	5.60	5.99	5.79	9.08	6.3	5.6
Colour	Co. less	Co. less	Co. less	Co. less	Co. less	Co. less	Co. less	Co. less	Co. less	Co. less	Co. less	Co. less
Dissolved Oxygen (4.6-6 mg/l)	7.1	7.44	8.5	8.60	8.72	9.2	7.04	8.21	8.36	5.9	2.9	6.3
BOD (30 mg/l)	128	123	102	93	91	74	131	119	116	130	141	152
COD (250 mg/l)	325	318	252	241	234	193	344	295	297	102	141	153
TDS (0-2000 mg/l)	3880	4560	2630	2612	2640	2857	3246	3828	3720	3990	5730	3510
TSS (30-500 mg/l)	400	428	140	120	160	86	380	386	320	320	316	360
Chloride (0-30 mg/l)	40	60	30	34	38	33	50	56	50	62	59	65

Figures in Parentheses represents WHO standards

Various Physico-chemical and biological parameters analysed include colour, Electrical Conductivity (EC), Total Dissolved Solids (TDS), pH, Total Suspended Solids, Chemical Oxygen Dissolved (COD), Biological Oxide Dissolved (BOD), and Chloride, Dissolved Oxygen. The values were compared with the WHO standard values. Of the Physico-chemical and biological parameters studied and variations observed from the testing of samples. The standard value of pH is 6.5 – 8.5 according to WHO standards, whereas values vary from 7.22 to 9.42 in the tested samples. The pH value was highest in Anaipalayam (9.42) which is more than WHO's standards and in other areas more or less it is equal to standard levels.

The standard value for Electrical Conductivity (EC) is 1500 according to WHO Electrical conductivity of water is a direct function of its total dissolved salts. Hence it is an idea to represent the total concentration of soluble salts in the water. In our study, the EC value varies between 1.35 dS/m in Kathakanni (site – III) which is lowest and raises up to 9.08 dS/m the highest in Anaipalayam (Site – I). The highest conductivity recorded in Anaipalayam was found to exceed the WHO standard and the variation is less in other areas.

Nine out of 12 samples tested found to have Dissolved Oxygen (DO) value greater than the permissible limits. The highest DO is in Kathakanni (9.2 mg/l) and lowest in Anaipalayam (2.9 mg/l). This may be attributed to the seepage of effluents from the industries to the groundwater.

Biological Oxygen Dissolved (BOD) is equivalent to the amount of oxygen required by aerobic micro-organisms to decompose the organic matter in a sample of water. The range of BOD is highest in all the 12 samples. The biological oxygen dissolved is highest (152 mg/l) in Anaipalayam and less in Kathakanni (74 mg/l).

The standard value of chemical oxygen dissolved is 250 mg/l according to WHO standards. In our observation, the COD ranges between 102 mg/l to 344 mg/l. The highest COD of 344 mg/l was recorded in the sampling site of Nallur was found to exceed the WHO standards. In other sites the variation is least.

Out of 12 samples, collected from the study area, 11 samples are found to have the highest value of TDS above the permissible limits of 500 to 2500 mg/l of WHO standards. Moreover, the excess TDS value could be due to dissolved solid waste originated from the discharge of the effluents from the dyeing industries. Particularly, the water sample which is collected at Anaipalayam showed high TDS value in the range of 5730 mg/l and it is responsible for groundwater pollution. High concentration of TDS may affect persons, who are suffering from Kidney and Heart diseases.

The Total Suspended Solids (TSS) value in the study area varies from 86 mg/l to 428 mg/l, but the permissible limit is between 30 mg/l to 500 mg/l. All the samples are within the range of permissible limits.

Chloride is widely found element in all types of rocks in one or the other form. Its affinity towards Sodium is high. Therefore, its concentration is high in groundwater, where the temperature is high and rainfall is less.

The result indicates that the quality of water considerably varies from one sample site to another. This wide variation is because of salinity and other dissolved materials from the nearby dyeing, bleaching and textile units in the study area.

Effects of Water pollution on Employment

While industrial pollution imposes severe negative externalities on rural communities, advent of industries in the region could possibly lead to some positive externalities such as employment and income generation. On the other hand, loss of employment due to the reduction in area under cultivation is another negative impact (Reddy and Behra 2006).

Table 7 - Effects of water pollution on Employment

Size of land Holdings	Industrial Employee	Textile units	Wage labourer	Own business	Others	Total
Large Holdings	4 (21)	16 (25)	0	5 (50)	1 (3)	26 (19)
Marginal Holdings	5 (26)	23 (36)	10 (83)	3 (30)	13 (45)	54 (41)
Medium Holdings	4 (21)	6 (9)	0	0	2 (7)	12 (9)
Small Holdings	6 (31)	19 (30)	2 (17)	2 (20)	13 (45)	42 (31)
Total	19 (100)	64 (100)	12 (100)	10 (100)	29 (100)	134 (100)

Source: Primary survey

From the study, most of the households who were depending on agriculture have shifted their occupation to industry, textile units, business and others. Employment in agriculture was declining year after year and the most affected were the marginal farmers. There are some farmers who were still cultivating their farmlands, but their heirs had shifted their occupation.

Conclusion

Based on the research analysis and the available secondary information, it is identified that the villages selected for study along the Noyyal River basin are polluted due to discharge of industrial effluents. To understand the environmental assessment of industrial effluent irrigation on groundwater quality of the adjacent farmlands, an exploratory study has been carried out using both primary and secondary information. The assessment of variables related to social and economic perception of farmers is difficult because there is possibility of overestimating the findings. Moreover, the effects due to permanent discharge of effluents to the farm lands and Noyyal River are difficult to assess.

From the study, nearly one-half of the respondents' stated that the water available was not suitable for agriculture. The water characteristics like turbidity, salinity, colour and odour has been changed and also affects the farming operations. Seventy-five percent of the farmers inferred that, their water contains more turbidity and salinity. Since, the farmers shifted their cropping pattern to the extent of water availability. Most of the farm households changed to salt tolerant cropping system in their lands and the farmers shifted their occupation from agriculture activities to non-farm activities. Maximum of thirty six per cent of the marginal farmers worked in textile units. Forty five per cent of small farmers were engaged as accountants, government employees, computer centre operators, etc.

The issues assume tremendous importance as groundwater pollution has become a major challenge in national resource management. Once upon a time, farmers' always depended on Noyyal River and open well for irrigation, but now they depend on bore wells and rain water for their farm cultivation. It is also deteriorated due to groundwater pollution. Majority of the population have shifted to jobs in the industry leaving agriculture. It is obvious that though passing of laws and creating institutional structures are obligatory, however it is not adequate to tackle the environmental issues. Regulations must be implemented related to sensitivity of the agriculturists. Institutions should be physically powerful, with more sovereignty and powers, to covenant with the problems so as to provide practical solutions.

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