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Tannery Wastewater affects the Drinking Water Quality and Heavy Metals in the Palar River Water Pollution in Vellore District Tamil Nadu

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Abstract

A large number of chemicals are used in the tanneries to convert the rawhide into finished leather. The chemicals used by the tanneries are ends in wastewater. This wastewater is dumped into nearby rivers and canals that create water pollution heavy metals in the water. The aim of this process is to access the chemicals used in the tannery industry post tanning process and to evaluate the drinking water quality of the wastewater released by the tanneries in the Palar river basin in Vellore district Tamil Nadu. To analyze the perception of the people in the study area affected by health due to wastewater from the tanneries. This study was performed as a cases study of the current drinking water sources used by households and how they perceive the quality of water. The second objective is to analyze the relationship between water quality and health hazards among households in the Vellore district. Primary data was collected from the respondents with the help of a questionnaire, total sample size of the respondent was 500, multistage random sampling technique was used to collect the data with the help of questioner method, the descriptive and statistical tools were used to analyse the data with SPSS and R statistical packages. The result shows that the people in the river basing suggested controlling the wastewater for the tanneries, and they demanded compensation from the tanneries. Finally, to suggest policy measures to control the water pollution in the study area.

Keywords: Water quality, Leather industry, Tannery, Tanning, Health, Environment, Pollution

Introduction

The presence of water makes the earth unique and is the sole basis for life on this planet. The demand for freshwater is expected to increase rapidly because urbanization and economic development increased the high demand for water supply (Maude et. al. 2007). Water is a scarce resource it is essential to achieve sustainable development (Tiwari and Dinar 2002). Sustainable development goals 5 and 6 emphasized providing quality water to all the citizens (SDGs 2015). Climate change water pollution from industries affects the groundwater quality and depletion is the major problem in developing countries. The Central Groundwater Board found out that 13 percent of the villages were water depleted regions, the cropping intensity decline by 7 percent it reduced yield and cropped areas in India. Groundwater pollution by large and medium industries poses a serious environmental threat, especially due to soluble inorganic matter (Krishnaswamy and Haridan, 1981). India ranking global water quality 120 places and environmental quality 168 the place as per Global Water Index 2021, if the polluting industries are located at the upper reaches of the watercourses or in uplands; the total livestock population accounted for 4.60 percent in 2019 the total population was 536 in 2019 (Livestock survey 2019). In Tamil Nadu the total livestock population was 17.65 percent in 2019 respectively (Livestock Census 2019).

The Indian leather industry constitutes a major economic activity providing direct and indirect with its large-scale employment. Because of the demand for leather products, leather industries play a predominant role in the world economy (Kanagaraj et.al. 2015. Li, et. al. 2019). The industry provides employment mainly from socially and economically backward societies to the tune of 1.4 million. Similarly, the export earnings of the industry were 59 million US$ in 1960-61 and now it is expected to get multiplied from 2424 million US$ in 2019-20. The country's share of total export value was 9 percent in 2019-20 (Economic survey 2019-20). The total number of tanneries in India was 2091in 2019 (Central pollution control Board, 2015). In Tamil Nadu accounts for 934 in 2019, leather exports account for 30 percent and 70 percent of leather production in the country (Central Leather Research Institute 2015). In Vellore district the total number of leather industries is 35 tannery units was 650 and 300 dying units the total export of 600 cores in the year 2019 (Faiyaz Ahemed 2020). The post –tanning denominated as the wet finishing performed in a water medium and aim to provide proper texture and structural properties to the leather, touch and colour qualities and to impart desired chemical physic mechanical and fastness properties; post tanning consists of the chemical process of de acidulation, retaining dyeing, fat liquoring and fixing. Refer fig1. Totally 130 different chemicals are used by the leather industry (Sawalha et.al., 2019). The main parameters evaluated are chemical oxygen demand (COD), Biochemical oxygen demand (BOD), total dissolved solids (TDS), chromium nitrogen, ammoniac nitrogen (NH4-N), conductivity, chlorides and sulphates (Everton Hansen, Partice Monteiro deAquim, Alana Witt Hansen, 2010). Wastewater from the tanning industry contains heavy chemicals, Hassen and World Emanuel reported that the wastewater quality from various tanning processes does not comply with the discharge limits of water that can be discharged to the sever network.

A recent study by Tasca .A.C. (2019) studied that the tanning process leads to the concentration of metals and chemicals in the tannery sludge create water pollution. Heavy metals and sediments in the tannery wastewater contaminated the river's ecosystem (Mir Mohamed 2016). Post- tanning process accounts 30 percent of contaminates effluents from the tanneries (Tang et al 2018). The pollutant discharge causes widespread organic and toxic pollution with severs ecological destruction (Miao et al 2012). Liu explains that the discharge of dyes from tanneries increases the potential danger of bioaccumulation, pollutes aquatic systems, and jeopardizes the environment (Liu et al., 2015, Peng et. al, 2016, Tang et al., 2019). Water pollution has increased in health risks and health impact shows that water-borne diseases like hepatitis, cholera, dysentery, cryptosporidiosis, giardiasis, diarrhoea and typhoid,(Miller,2015., Roushdy et.al ,2012). Gyan Chandra and Kashyap conducted a study on tannery workers in the Kanpur leather industry in India study concluded that a large number of tannery workers are affected by asthma, tuberculosis and chronic bronchitis (Gyanchandra Kashyap, Shrikant Sing,2021). Water pollution from tannery wastewater is the major source of morbidity and mortality in developing countries (Qingwang, 2016). However, physic chemicals are applied in leather, especially in the post- tanning process, which released many waste water discharges into the river. This paper aims to carry out the chemicals used in the leather post tanning process and to evaluate the water pollution in the Palar river.

Research Objectives

The aim of the study is to understand the process of post leather tanning and to analyse the water pollution in the Palar River. The current drinking water sources used by households and how they perceive the quality of water. The second objective is to analyse the relationship between water quality and health hazards among households in the Vellore district.

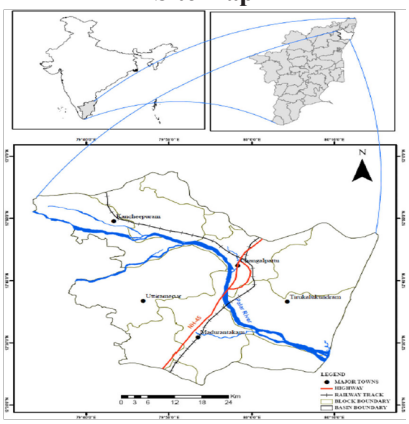
Materials and Methods

This chapter is divided into three major parts. The first part describes the Study Area followed by a description of Palar River; the second part briefly describes the Leather industry waste water discharge from Palar River. The third part describes the sample villages, which are chosen by the researcher at random for the investigation.

Description about the Palar River

Nandi Durg, Kolar district of Karnataka is the originator of Palar River which passes through the southwestern region of Andhra Pradesh and Tamil Nadu and its flows in the four districts of Tamil Nadu, namely Tirupattur, Vellore, Thiruvannamalai and Kanchipuram. The length of the river is around 350 kms. The Palar drains an area of 18,300 km2 (10,910 km2 in TN) out of nearly 60 percent is in Tamil Nadu and the rest in the states of Karnataka and Andhra Pradesh. The potential supply is about 1500 million cubic meters (MCM) but the current demand is 2560 MCM. Hardly the river flows for 15 days in a year. Palar River is the major source of drinking in and around towns and villages and also water from the river is used for agricultural activities. The water of this basin is also used for industrial purposes (Sundar et al, 2010). The main type of industry existing in this basin is the leather industry.

Site map



Sources: Vellore district statistical department.

Leather Industry

The number of tanneries has increased during pre industrialization era i.e. 1970s, due to the banning of semi-finished leather. The geochemical quality of drinking water is deteriorating in the river bed because of the discharge of industrial effluent into this river. Pollution is more prevalent in the entire Palar basin and especially in Vaniyambadi to Walajah where a large number of tanneries are located nearby the upper part of Palar. Tanneries from this location release a large volume of untreated effluents in the river ecosystem which contaminates groundwater and soil.

Next to farming, many persons work in tanneries. Around 35 percent of Indian export earnings of the Indian leather industry sector come from 449 tanneries working in the Palar River basin. These units generate about Rs.15 billion a year and employ about 50,000 people. Tanneries discharge about 20 million litres per day (MLD) of effluent and 100,000 tons of salt per year. Groundwater quality is not fit for drinking or irrigation and over 15,000hectare of land is affected by high total dissolved solids (TDS). See table -1

Table 1 Water quality level at Study area

Parameter/ Area	pH	TSS	TDS	Chloride	Sulphate	BOD	COD	Total Chromium	Total Hardness	Alkalinity	
Tolerance Limit	6.5-8.0	500-1000	1500	250	250	NIL	NIL	0.05	75.-115		1.50
Vellore	8	12	1320	588	86	5	40	L	375	880	LMDL
Melvisharam	8.2	8	2804	1347	272	2	24	0.3	220	960	LMDL
Arcot	7.4	16	2488	1446	243	4	40		150	670	LMDL
Ranipet	8.3	12	2036	693	558	3	24	0.64	170	420	LMDL
Walajah Road	7.8	8	960	346	158	3	30		125	360	LMDL
Pallikonda	8.6	12	940	485	129	3	40	L	310	200	210

Source: Tamil Nadu Pollution Control Board, 2019.

Note: LMDL- Less than the minimum detectable limit.

Table-1 shows that the tanneries wastewater and the chemicals in the water all the blocks in the district, tannery water quality parameters like ph, TDS, Chloride, Sulphate, Chromium, hardness and Alkalinity and Florid of the Palar river water from tanneries were measured. The water samples were collected from the spot and all the parameters were tested in the water testing lab in the Vellore district. As was expected, the highest value of TDS in Vellore was 1320, Melvisharam 2804, Arcot 2438, Ranipet 2036. The chloride was observed 1446 in Arcot 1347 in Melvisharam and other towns. It was very high.

Regarding the sulphate was highest in Melvisharam 272 and Ranipet 558, respectively. In the present study, the harden limit was high in Vellore town area375, Melvisharam 200, Arcot 150. The average concentration of Alkaline was high in Melavisharam960 and Vellore 880, respectively. To conclude that water contamination and the tolerance limits were very high in Melvisharam, Ranipet and Pallikonda blocks. The TDS limits are also very high in Vellore Melvisharam, Arcot and Ranipet.

Table 2 Tamil Nadu State tanneries processing capacity and wastewater discharge

State	Area of Concentration	Approx. total processing capacity in tonnes of hide/ day	Estimated range of wastewater discharge in m3 per day
TamilNadu	Chennai, Ranipet, Ambur, Pernampet, Vaniyambadi, Dindugal, Trichy	550	15000-20000
Total		**550**	

Source: Central Pollution Control Board, New Delhi.

Table 2 shows that Tamil Nadu State tanneries processing capacity and wastewater discharge Approx. Total processing capacity in tonnes of hiding/ day 550. It was estimated range of wastewater discharge in m3 per day15000-20000 Lit. This is very high compare to all the other states in India.

Chemical properties of groundwater samples

The chemical properties of groundwater samples collected by Tamil Nadu Water and Drainage Board, Vellore, from Palar River Basin of Vellore District are below.

pH

The pH of the groundwater samples of Vellore District varied from 4.13 to 9.46. Among the eight taluks, Gudiyatham taluk recorded the lowest mean pH of 7.11, while the highest mean pH of 7.87 was observed in Arakkonam taluk. The mean ph values for groundwater registered in the ascending order were Gudiyatham (7.11), Tirupattur (7.22), Arcot (7.25), Walajah (7.26), Vaniyambadi (7 .43), Vellore (7.48), Katpadi (7.78) and Arakkonam (7.87).

Electrical Conductivity (EC)

The EC of the groundwater sample ranged from 0.15 to 8.39 dS m-1 (which means Deci Siemens per metre). The mean EC recorded in the eight taluks in the descending order were Gudiyatham (5.65 dS m-1), Tirupattur (4.68 dS m-1), Katpadi (4.56 dS m-1), Vellore (4.47 dS m-1), Vaniyambadi (4.32 dS m-1), Wallajah (3.53 dS m-1), Arcot (2.22 dS m-1) and Arakkonam (1.02 dS m-1).

Total Dissolved Solids

The groundwater samples of the Palar River Basin of Vellore showed a wide variation of total dissolved solids ranging from 96 to 5626 mgL-1 (milligrams per liter). Considerable variations were observed among taluks. The mean values of total dissolved solids recorded were 651, 1423, 3166, 2921, 2996, 2764, 2684 and 2258 mg L-1 in the taluks of Arakkonam, Arcot, Gudiyatham, Katpadi, Tirupattur, Vaniyambadi, Vellore and Walajah, respectively.

Total Chromium (Cr)

The total Cr of the groundwater samples of Vellore District varied from 23 to 308 mg L-1. Among the eight taluks, Tirupattur taluk recorded the lowest mean value of 50 mg L-1, whereas the highest mean of 114 mg L-1 was observed in Vaniyambadi taluk. The mean total Cr values for groundwater samples registered in ascending the order were Tirupattur (50

mg L-1), Arakkonam (61 mg L-1), Gudiyatham (68 mg L-1), Vellore (73 mg L-1), Katpadi (95 mg L-1), Walajah (111 mg L-1) and Vaniyambadi (114 mg L-1). Among the different taluks,

Hexavalent Chromium (Cr (VI)

The groundwater samples from different taluks of Vellore district recorded a wide range of Cr (VI) from 7 to 192 ppm (parts per million). The village Chendathur in Gudiyatham taluk recorded the lowest value of 7 mg L-1. Vannivedu village in Walajah taluk recorded the highest total Cr values in groundwater (308 mg L-1). The range of Cr (VI) registered was 15 to 84, 18 to 127, 7 to 171, 21 to 190, 10 to 34, 26 to 184, 8 to 172, and 25 to 192 mg L-1, respectively in the taluks of Arakkonam, Arcot, Gudiyatham, Katpadi, Tirupattur, Vaniyambadi, Vellore and Walajah.

Water-Related Diseases

Acute Diarrhoea Disease (ADD) is prevalent in many parts of the Vellore district. Gastroenteritis is the most prevalent disease in Vellore and Thiruvannamalai districts. Malarial fever is also a common disease and Iodine Deficiency is a common problem in Vellore city and the Vaniyambadi region of Vellore district.

Places of Water Scarcity and Polluted Water

Water pollution and water scarcity are experienced by the entire district, but some villages are extremely affected by the tanneries and other industries. (Tamil Nadu Water and Drainage Department, 2020).

Walajahpet Taluk

Because of the industrial development, there is a lot of pollution both in water and air. Vannivedu is one of the most polluted places where the water has the highest level of Chromium and other metals. Narasinghapuram and Manthangal are also other most affected villages.

Vannivedu

Due to water pollution which affected cultivation, only a small section of the village population depends on agriculture. Water by appearance look contains the highest level of pH and Cr. People of Vannivedu report getting skin allergy, formation of stones in kidney etc.

Narasinghapuram

According to the residence, water quality is good but high levels of Cr and other metal content are found in that water. Residents of this village report thyroid disorder, kidney stones etc.

Nandhiyal Village

The water quality. The level of pH and other metals like chromium etc. are remarkably high. Skin diseases and the formation of stones in the kidney are common health problems reported by residents of this village.

Vaniyambadi Taluk

Leather tanning and leather goods manufacturing are the main occupations in this town. There are clusters of tanneries situated in and around the town. According to the groundwater testing reports, villages Udayendram, Valayampattu, Girisamudram and Sathambakkam are highly polluted due to tannery effluents.

Girisamudram

Water is supplied to this village for four hours. This village is the beneficiary of Hoggenakal Drinking Water Project.

Valayampattu

Water is available twice a week for 1 hour through 11 taps. This village gets water from Mettur Integrated Drinking Water Project.

Water Charges

All the connections in the town are unmetered. Flat charges are collected from the users. The tariff and deposit charges collected by the Town Panchayat are provided in the following table.

Table 3 Water Supply Charges

Type of collection	Deposit charges	Tariff charges
Residence	3500	55
Commercial	7000	100
Industries	7000	100

Source: City Corporate.

Kangeyanallur

Drinking water is supplied through public taps for one hour every day **Virudhampattu**; This village gets water from Mettur Integrated Drinking Water Project. This village comes under Hogenakkal Integrated Drinking Water Project. **Vaduganthangal.** Every day nearly one hour, water is supplied through the public tap. **Pernampattu Taluk**: the economy is dependent on the leather industries, glue factories as well as beedi factories. Many locals people were working in these industries. Some villages are worst affected by the tannery effluents. According to the groundwater testing reports, villages Alinjikuppam, Redimankuppam, Kailasagiri, Valayampattu, and Pernampattu town are highly polluted due to tannery effluents. Ambur: Leather tanning and leather goods manufacturing are the main occupations in this town. According to the groundwater testing reports, they are highly polluted due to tannery effluents. (Pollution Control Board, Vellore, 2019).

In this chapter, the nature of the study area – both rural and urban areas was described. In some villages, water supplied to the residents is not only sufficient but also highly polluted. Tanneries and sand mining are the main cause of the water scarcity and pollution in this district. Tamil Nadu Government is introducing many schemes to improve the water condition in the district.

Chemical Properties of Soil Samples

Soil Survey and Land Use Organization of Tamil Nadu has collected the samples from the Palar river basin.

Soil pH

The pH of the soil of the Vellore district varied from 6.10 to 9.44. Among the eight taluks, Tirupattur taluk recorded the lowest mean pH of 7.57.72, while a high level of 8.12 was observed in Walajah taluk. The mean pH values for soil registered were in the ascending order are Tirupattur (7.57), Arcot (7.72), Arakkonam (7.73), Gudiyatham (7.98), Vaniyambadi (7.99), Katpadi (8.01), Vellore (8.08) and Walajah (8.12). Among different taluks, Vannivedu village in Wallajah taluk recorded the highest pH value of 9.44 in soil.

Electrical Conductivity (EC)

The EC of the soil ranged from 0.09dS m- 1. The main EC recorded in the eight taluks in the ascending order of Arakkonam were (0. 19dS m- 1.), Arcot (0. 29dS m- 1.), Katpadi (0. 19dS m- 1.), Vaniyambadi (0. 36dS m- 1), Gudiyatham (0. 37dS m- 1), Tirupattur (0. 39dS m- 1), Vellore (0. 44dS m- 1), Walajah (0.98dS m- 1). The lowest value of EC (0. 09dS m- 1) was recorded in Kannikapuam village of Arakkonam taluk and the highest value (1.91dS m- 1.) in Vannivedu village of Wallajah taluk.

Organic Carbon

The soil of the Palar River basin of Vellore District was low to high in organic carbon content and showed a wide variation ranging from 0.01 to 1.08 percent. Considerable variations were also observed among taluks. Tirupattur taluk recorded the highest mean organic carbon content (0.67 percent), while Gudiyatham, Katpadi and Vaniyambadi taluks recorded low status (< 0.50 per cent) of organic carbon values. The mean value of organic carbon recorded was 0.55 per cent in Arakkonam, 0.56 per cent in Arcot, Vellore and Walajah taluk - 0.58 per cent.

Cation Exchange Capacity (CEC)

The amount of CEC ranged from 5 to 30 cmol (P+) kg-1 in Palar River basin of the Vellore district. The highest (30 cmol (P+) kg-1)and the lowest (5 cmol (P+) kg-1) CEC content were noticed in Walajah and Vellore taluks, respectively. The mean values of CEC were 22,16, 17,18,19,17 and 5 cmol (P+) kg-1 in the taluks of Arakkonam, Arcot, Gudiyatham, Katpadi, Tirupattur, Vaniyambadi, Vellore and Walajah taluks, respectively.

Total Chromium (Cr)

The total CR of Palar River basin of the Vellore district varied from 31 to 2579 mg kg-1. Among the eight taluks, Walajah taluk recorded the highest mean (1351 mg kg-1), while the lowest mean was recorded in Arakkonam taluk (766 mg kg-1). The mean values of soil registered in the ascending order were Arakkonam (766 mg kg-1), Arcot (783 mgkg-1), Gudiyatham (848 mg kg-1), Katpadi (863 mg kg-1), Tirupattur (1077 mg kg-1), Vellore (1230 mg kg-

1), Vaniyambadi(1334 mg kg-1) and Walajah (1351 mg kg-1).

Hexavalent Chromium (Cr (VI))

The soil samples from different taluks of Vellore district recorded a wide range of Cr (VI) from 9 to 1996 mg kg-1. The village in Ammanakuppam in Gudiyatham taluk recorded the lowest value of 9 mg kg-1. The highest chromium content of 1996 mg kg-1 was recorded in Vannivedu village of Walajah taluk. The range of Cr (VI) registered were 41 to 612, 10 to 650, 9 to 1603, 16 to 1482, 215 to 1074, 316 to 1127, 266 to 1077 and 305 to 1996 mg kg-1 in the taluks of Arakkonam, Arcot, Gudiyatham, Katpadi, Tirupattur, Vaniyambadi, Vellore and Walajah, respectively..

Theoretical Framework

The data collected from primary and secondary sources are analyzed with the help of relevant techniques. Tools are selected and used after assessing the nature of the primary data collected. The data were collected from 500 respondents, the questionnaire was used to collect the data, the data was analyzed using Chi-square with the help SPSS and R. Descriptive statistical measures were used to compare the socio-economic characteristics, percentage distribution across gender, level of education, region-rural and urban were also estimated. The following formula is used to estimate descriptive statistics. Chi-square is used to find out the association among the attributes.

Stepwise method: this is the method used to select the subset of explanatory variables when they are large in number. In this method, in each step, explanatory variables are one by one added or deleted. The most common criterion for the addition or deletion of variables in stepwise regression is based on partial F-statistics.

$$\frac{SSR_{Full}-SSR_{Reduced/q}}{SSE_{Full}} = R^2_{Full-RReduced} \quad 1-R^2_{Full}$$

$$\frac{n-p-1}{q} = \frac{n-p-1}{q}$$

The suffix Full refers to the larger model with p explanatory variables, whereas the suffix Reduced refers to the reduced model with (P-q) explanatory variables.

Results and Discussions

Socio Economic Characteristics

The distribution of socio economic characteristics (Table-1) in the study area shows that out of 500 respondents, the majority Age: All the respondents belong to the age group of above 20 years and below 67 years and the mean age is 40.76 (Table 4) which reflects that the respondents are in the middle age group. Out of the total respondents, 42 percent are males and 58 percent are females. Eighty-two percent of the respondents are below-50 age group

Women are the ones who take care of domestic works and hence may be in a position to decide household in the present study, a little more than half of the respondents are females. Education,

The literacy level of the household member determines their awareness about the quality of water and its consequences. This also enables them to get look for quality water from proper sources. The table reveals that 98 percent of the respondents have gone to schools and colleges, whereas the remaining two percent did not go to school. While a larger percentage of the respondents have undergone educational training up to higher secondary school level, only eight percent completed higher education. Among them, five are postgraduates and nine are professionally qualified.

Table 4: Socio Economic Characteristics

Socio Economic Variables	Male	Female	%
Gender			
Male	88.57	11.43	100
Female	28.97	71.03	100
Age			
Less than 30	45	59	104
31 to 40	56	100	156
41 to 50	68	81	149
51Above	41	56	97
Total	210	290	500
Educational Level			
Illiterate	27.27	72.73	100
Primary	27.63	72.37	100

Secondary	46.99	53.01	100
Higher Secondary	45.68	54.32	100
Diploma	44.90	55.10	100
Degree and above	53.84	46.16	100
Occupation			
Government Employee	4		4
Private Employee	23	36	59
Agricultural worker	31	19	50
Daily wage labour	151	101	252
Others	22	113	135
Total			100
Household Income			
Less than 50000	13	13	26
50001 to 100000	140	103	343
100001 to 300000	77	45	122
300001 to 500000	4	3	7
Above 500000	0	2	2
Total			500

Source: Primary data

The monthly income of the household is taken as an economic factor in the study. As the income of each member in a household increases, the demand for water and the consumption of water for household use also increases. This also indicates that the households' willingness to pay also increases with the increase in income.

Twenty-six percent of households are not affected by water-borne sicknesses during the year 2019 – 2020. In 64 percent of the sample households, only the health of only one person is affected. About 10 percent of households reported that two persons in their families were affected.

Seventy-five percent of the sample households are reported that they were affected by some or other 14 different health problems. Among these, a large section of sample households is affected by diarrhea and skin diseases. 18.2 percent of the sample households are frequently affected by diarrhea and 10.6 percent are affected by skin problems. Other important health problems reported by respondents are frequent attacks of cold and cough (7.2 percent), allergy (6.4 percent), gastroenteritis (6.2 percent) and kidney stones (5.4 percent).

About an early one-third of sample households reported being affected by water-borne sickness for only three days. One alarming observation in the study is that nearly 10 percent of sample respondents are affected by water-borne sickness for more than three months.

Quality of Water as Perceived by Households

In many places, the available water has been rendered unsafe for domestic consumption. In the Vellore district, such a thing has happened by the tanneries. The quality of water has become very poor. In some areas, even the colour has changed and a lot of presence of dust. . The result also shows that many blocks are found to have high chromium and other metal concentration in the groundwater.

Table 5 Sample Households in Rural and Urban Areas

Location	Mean	S.D	Minimum	Maximum	Range
Urban (250)	0.50	0.50	0.00	1.00	1.00
Rural (250)	0.50	0.50	0.00	1.00	1.00

Source: Primary Survey, Vellore District

The table reveals that the sample consists of an equal number of households from both urban and rural areas. Dummy variables for the location of the sample households are taking the value of 1 for urban and 0 for rural. Since the sample size is equal, Mean, Standard Deviation etc., are the same. Out of 10 sample wards, five wards are urban wards and five wards are from the rural area. An equal sample size from rural and urban is helpful to compare people's willingness to pay for improved water and other variables. This study facilitates to know how the location influences the people's mentality.

Table 6 Perception of Water by the Households

Perception by the household	Score given
Below average	1
Average	2
Good	3
Very good	4

Source: Primary Survey, Vellore District

Table 7 Household Perceptions about the Quality of Water

Characteristics of water	Perception of Households			
	Below Average	Average	Good	Very Good
Colour	1	418	78	3
Dust	1	396	99	4
Clean or polluted	1	397	98	4

Source: Primary Survey, Vellore District

The table shows that about 80 percent of respondents have perceived all the three aspects of water quality as 'average' while the remaining 20 percent perceived it as 'good'. The number of respondents who said 'below average' or 'very good' is negligible. The next table gives the descriptive statistics of the scores for each aspect as perceived by the households.

Table 8 Descriptive Statistics for the Quality Aspect of Water

Quality aspect of water	Descriptive statistics				
	Mean	Std. Deviation	Range	Minimum	Maximum
Colour	2.17	0.393	3	1	4
Dust	2.21	0.433	3	1	4
Clean or polluted	2.21	0.432	3	1	4

Source: Primary Survey, Vellore District

The table reveals that all the three aspects of water quality, namely, color, dust, and clean or polluted mean scores range between 2.17 and 2.21 while the standard deviation ranges between 0.393 and o.433. The higher standard deviation for the 'clean or polluted' category shows that respondents' views widely differ on this aspect.

Quality index: The average of the three scores as given by was computed for each respondent. Here, and are the scores corresponding to color, dust, clean or polluted, respectively. This average score is termed the 'Quality Index' and is included as a variable in the analysis. For our data set, the Quality index had a mean value of 2.196 with a standard deviation of 0.395.

Location Versus Incidence of Water-Borne Sickness: Tests of Association between Attributes

To test whether there is an association between location, viz., urban and rural and incidence of water-borne diseases, a chi-square test was performed. The classification table is given below:

Table 9 Household Locations and Incidence of Water Borne Disease

Incidence of WBS	Location		
	Rural	Urban	Total
No	66	93	159
Yes	184	157	341
Total	250	250	500

Source: Primary Survey, Vellore District
WBS=water borne diseases

Out of 250 respondents in rural areas, 184 (73.6%) had water borne diseases whereas, in urban area, only 157 (62.8%) were affected by water-borne diseases. The results of the chi-square test are shown below:

Table 10 Results of Chi-Square Tests

Tests	Value	df	Asymp. Sig. (2-Sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.723	1	0.010		
Continuity Correction	6.234	1	0.013		
Likelihood Ratio	6.747	1	0.009		
Fisher's Exact Test				0.012	0.006
LinearbyLinear Association	6.709	1	0.010		

Source: Primary Survey, Vellore District

All chi-square tests showed a strong association between the two attributes as indicated by the respective p-values. The results were confirmed by using Z-test for testing the significance of two proportions with p1=0.736 and p2=0.628. n1=250=n2. The corresponding Z-statistics was Z=2.5928 with p-value=0.009519. This means that respondents in rural areas are more prone to water borne diseases than those who dwell in urban areas. The important conclusions are incidence of water borne diseases is related to the quality of water. The above results indicate that all the aspects are associated with health. It explains that the quality of water and health of the households are positively related.

Conclusion

Pollution by tanneries must be checked and damages must be compensated and corrected, but this can be done only by the collective efforts of the government, tanneries owners and the households affected. The Common Effluent treatment plant (CETP) should be set up in all the tanneries. The small tanneries had neither the space nor the financial ability to build individual Effluent Treatment Plant (ETP), so they can merge with the Common effluent treatment plant, building a collective treatment plants. Institutional agencies have to formulated standards and regulations for tanneries to discharge the chemicals, heavy metals into the rivers.

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References

Barlow Maude. *Blue, Covenant: The Global Water crisis and the Coming Battle for the Right to Water*. New Press, 2008.

Cutter, David M., and Grant Miller. "The Role of Public Health Improvements in Health Advances, the Twentieth Century, United States." *National Bureau of Economic Research*, 2005.

Daddi, Tiberio, et al. "Enhancing the Adoption of Life Cycle Assessment by Small and Medium Enterprises Grouped in an Industrial Cluster: A Case Study of the Tanning Cluster in Tuscancy, Italy." *Journal of Industrial Ecology*, vol. 20, no. 5, 2016.

Ebenstein, Avraham. "The Consequences of Industrialisation Evidence from Water Pollution and Digestive Cancers in China." *The Review of Economics Statistics*, vol. 94, no. 1, 2012, pp. 184-201.

Kashyap, Gyan Chandra, et al. "Prevalence and Predictors of Asthma Tuberculosis and Chronic Bronchitis among Male Tannery Workers: A Study of Kanpur City in India." *Clinical Epidemiology and Global Health*, vol. 9, 2012, pp. 71-77.

Hassen, Abdrie Seid, and Tesfalem Belay Woldamanual. "Evaluation and Characterization of Tannery at Batu and Modjo Tannery, Ethiopia." *International Journal of Rural Development, Environment and Health Research*, vol. 1, no. 3, 2017, pp. 1-10.

Janakarajan. S. "In search of Tanks: Some Hidden Facts." *Economic and Political Weekly,* vol. 28, no. 26, 1993, pp. 53-61.

Kilic, Eylem. et al. "Environmental Optimization of Chromium Recovery from Tannery Sludge using a Life Cycle Assessment Approach." *Journal of Hazardous Materials*, vol. 192, no. 1, 2011.

Loraine Kennedy. "Co-operating for Survival: Tannery Pollution and Joint Action in the Palar Valley India." *World Development*, vol. 27, no. 9, 1999.

Lu, Yonglong, et al. "Impacts of Soil and Water Pollution on Food Safety and Health Risks in China." *Environment International*, vol. 2, 2015, pp. 5-15.

Miao, Y., and C. Fun. "China's Water Environmental Problem and Improvement Measures, Resource." *Economic Environment Protection*, vol. 3, 2012.

Ali, Mir Mohammed, et al. "Preliminary Assessment of Heavy Metals in Water and Sediment of Karnaphuli River, Bangladesh." *Environmental Nanotechnology, Monitoring*

and Management, vol. 5, 2016, pp. 27-35.

Wang, Qing, and Zhiming Yang. "Industrial Water Pollution, Water Environment Treatment and Health Risks in China." *Environmental Pollution*, vol. 30, 2016, pp. 1-8.

Rajagopal, A and Vaidyanathan. *Condition and Characteristics of Ground Water Irrigation in the Palar Basin: Some Preliminary Results*. Madras Institute of Development Studies, 1998.

Agricultural Research Station Virinjupuram, https://tnau.ac.in/ars-virinjipuram

Roushdy, Rania, et al. *The Impact of Water Supply and Sanitation on Child Health, Evidence from Egypt*. New York Population Council, 2012.

Tamil Nadu Pollution Control Board, https://tnpcb.gov.in

Tasca, Andrea Luca, and Monica Puccini. "Leather Tanning: Life Cycle Assessment of Retanning, Fatliquoring and Dyeing." *Journal of Cleaner Production*, vol. 226, 2019, pp. 720-729.

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