International Journal of Current Research and Academic Review

ISSN: 2347-3215 Volume 4 Number 8 (August-2016) pp. 183-197

Journal home page: http://www.ijcrar.com

doi: http://dx.doi.org/10.20546/ijcrar.2016.408.015

Externalities of Sewage Pollution in Madurai District of Tamil Nadu, India

J.S. Amarnath* and U. Sridevi

Department of Agricultural Economics, Tamil Nadu Agricultural University, Agricultural College and Research Institute, Madurai, India

Corresponding author

KEYWORDS

Externalities, averting expenditure, fallow lands, land value, land quality, water quality, skin and lung diseases, milk decline and pollution intensity.

A B S T R A C T

The present study focuses on the externalities of sewage pollution in Madurai district. In Madurai, Sewage treatment plants (STP) are located at Avaniyapuram and Sakkimangalam with a capacity of 125 MLD (Main layers depth) and 45.50 MLD respectively. The wastewater generation from Madurai City Corporation was 162.80 MLD in 2014 and this created various externalities in the district. The results showed the externalities of sewage pollution which included decline in cropped area, decline in crop income, increased fallow lands , increased years of fallow , yield decline in affected farms, reduction in land value, worsening water quality, increased incidence of health disorders, increased intensity of skin and lung diseases, increased severity of common diseases, increased averting expenditure for human health amelioration , milk decline, cattle diseases and increased defensive or averting expenditure for animal health amelioration, increased land selling and migration of family members. All these externalities increased with increase in pollution intensity. Solution to the sewage pollution problem should consider the intensity of these externalities and appropriate strategies like proper functioning of Sewage Treatment Plants with recycling should be attempted.

Introduction

In Madurai, Vaigai river is heavily polluted due to the discharge from the automobile industries, agricultural practices and improper discharge of domestic and animal wastes. In Madurai, Sewage treatment plants (STP) are located at Avaniyapuram and Sakkimangalam with a capacity of 125 MLD (Main layers depth) and 45.50 MLD respectively. The wastewater generation from Madurai City Corporation was 162.80 MLD in 2014 and would likely to be 338.70 MLD in the year 2044. In Avaniyapuram sewage farm, the crops were grown by waste water due to the scarcity of fresh water and due to the presence of nutrients in waste water but the presence of contaminants affect the consumers who consume the produces. Studies showed that there is accumulation of cadmium, chromium and lead in the sewage farm produce with long

term application of the waste water. This would seriously deplete essential nutrients in the body and further decrease immunological defenses. Hence this requires an investigation on the externalities of sewage pollution in Madurai district.

Methodology

Choice of the study area

Madurai district was selected purposively for the study since it faces sewage problem due to location of Sewage Treatment Plants. Among the thirteen blocks of the district, Thiruparangudaram block and Madurai East block are affected by sewage pollution due to location of sewage treatment plants in these blocks. Based on the intensity of the pollution as evinced from the electrical conductivity of irrigation water, the villages were classified into two categories namely seriously affected and low affected (Table 1).

In Thiruparangudaram block, Avaniyapuram village was selected for seriously affected category purposively whereas another village namely kaluvangulam was selected for low affected and Paraipatty village was selected for non affected area. Then from each category, 35 farmers were selected at random. In Madurai East block, Sakkimangalam village was selected for seriously affected category whereas another village namely Elamanur was selected for low affected and Nedungkulam village was selected for non affected category. Then from each category 35 farmers were selected at random. Thus the sample size constituted 210 farmers.

Result and Discussion

Externalities on cropping pattern in affected farms

The cropping pattern adopted in both Avaniyapuram and Sakkimangalam sample farms are presented in Table 2. When compared to non-affected farms, both seriously affected and low affected farms, registered lower area in paddy and the decline in area were 13.46 hectares and 6.53 hectares respectively in Avaniyapuram study area. In Sakkimangalam area also, the same declining trend was followed and the reduction in paddy area was 13.12 hectares and 6.26 hectares for seriously affected and low affected farms respectively.

Maize also registered decline in area in affected farms in both the study areas and the decline was 2.20 hectares in seriously affected farms and 1.72 hectares in low affected farms in Avaniyapuram study area. In Sakkimangalam study area also, the decline was 2.10 hectares and 1.22 hectares in seriously affected and low affected farms respectively. In seriously affected farms, sugarcane was not grown. In both the study areas, sugarcane registered lower decline in area in low affected farms as compared to non- affected farms and the decline was 15.88 hectares in Avaniyapuram study area and 13.40 hectares in Sakkimangalam study area.

Vegetables and fodder grass also registered relatively marginal decline in area in both the affected farms in both the study areas. Thus it could be concluded from the table that in both the affected areas, the decline in area was registered in all the crops grown due to the externalities of sewage pollution and also the decline in cropped area was increased with increase in pollution intensity.

Reduction in crop income of affected farms

The details of gross crop income of both Avaniyapuram and Sakkimangalam sample farms per hectare are presented in Table 3. It could be seen from the table that the non-

affected farmers had the higher per hectare gross crop income of Rs. 256786 and Rs. 215312 per hectare in Avaniyapuram and Sakkimangalam study area respectively. On the other hand, the farmers of both seriously affected and low affected farmers realized a lower per hectare gross crop income in both the study areas. The gross income of seriously affected farmers was Rs. 116814 and Rs. 105765 in Avaniyapuram and Sakkimangalam study area. The gross income of low affected farmers was Rs.188537 and Rs.165432 in Avaniyapuram and Sakkimangalam study area respectively. Thus the decline in the income of affected farmers increased from low affected (26.58%) to seriously affected (54.51%) in Avaniyapuram study area. The decline in the income of affected farmers increased from low affected (23.17%) to seriously affected (50.88%) in Sakkimangalam study area. Thus in both the study areas, the decline in gross crop income was observed in affected farms and the decline was increased with the pollution intensity prevailed in these farms.

Externalities on gross farm income of affected farmers

The details of gross income of sample farmers of Avaniyapuram and Sakkimangalam are presented in Table 4. Non-affected farmers registered a highest gross income of Rs. 178848 and Rs.165676 per farm in Avaniyapuram and Sakkimangalam study area respectively. Affected farmers registered a decline in gross income and the income decline was 40.14 per cent and 37.54 per cent for seriously affected farmers in Avaniyapuram and Sakkimangalam study area respectively. The said income decline was 22.50 per cent and 22.16 per cent for low affected in Avaniyapuram and Sakkimangalam study area respectively and thus it could be seen that the gross income had declined with increase in pollution intensity.

The crop income had also declined in affected areas and the decline was 51.12 per cent and 48.88 per cent for seriously affected farmers in Avaniyapuram and Sakkimangalam study area respectively. The said income decline was 25.62 per cent and 25.94 per cent for low affected farmers in Avaniyapuram and Sakkimangalam study area respectively. Thus the crop income had also declined with increase in pollution intensity

The animal husbandry income realized was higher with Rs. 19562 and Rs.18412 per farm for seriously affected farmers in Avaniyapuram and Sakkimangalam study area respectively and Rs. 9563 and Rs.10451 per farm for low affected farmers in Avaniyapuram and Sakkimangalam study area respectively. The increase in animal husbandry income for seriously affected farmers in Avaniyapuram and Sakkimangalam study area was 158.69 per cent and 149.45 per cent respectively. The increase in said income for low affected farmers in Avaniyapuram and Sakkimangalam study area was 26.46 per cent and 41.59 per cent respectively. Thus the affected farmers had undertaken increased animal husbandry activities to counter the loss in crop income due to sewage pollution.

The analysis of non-farm income revealed that the seriously affected farmers had realized the highest said income of Rs.5000 and Rs. 5500 in both the study areas of Avaniyapuram and Sakkimangalam study areas respectively followed by low affected farmers with Rs.3500 and Rs.3250 in both the study areas of Avaniyapuram and Sakkimangalam study areas respectively. The increase in non-farm income for seriously affected farmers over non-affected farmers in Avaniyapuram and Sakkimangalam study area was 100.00 per

cent and 107.55 per cent respectively. The increase in said income for low affected farmers over non-affected farmers in Avaniyapuram and Sakkimangalam study area was 40.00 per cent and 22.64 per cent respectively. Thus it could be concluded from the above analyses that the sewage pollution had led to decline in gross income and crop income of affected farmers. Also, the decline in this income had increased with increased in pollution intensity. To compensate the loss in crop income, the affected farmers had taken up animal husbandry activities and non-farm activities in both the study areas.

Land quality deterioration

Particulars relating to land quality deterioration in the serious and low affected farms of both Avaniyapuram and Sakkimangalam are presented in Table 5. The land quality index was fixed in a three point scale of one for poor land quality, two for average land quality and three for good land quality. The poor land quality was higher in seriously affected farms with a proportion of 94.29 per cent and 88.57 per cent and the average land quality was higher in low affected farms with a proportion of was 45.71per cent and 42.86 per cent in Avaniyapuram and Sakkimangalam study area respectively. The good land quality was also higher in low affected farms with a proportion of 22.86 per cent and 20.00 per cent in both the study areas respectively.

Thus it could be inferred from the table that the observed land quality was directly related to the prevailed pollution intensity in the study area. It could also be seen from the table that the proportion of seriously affected farmers who had undertaken soil testing was higher for seriously affected farmers with 65.60 per cent and 55.00 per cent as compared to 30.00 per cent and 45.00 per cent of low affected farmers in Avaniyapuram and Sakkimangalam study areas respectively. Thus this analysis proved that the soil testing undertaken by affected farmers were directly related to the pollution intensity.

Fallow lands and yield decline

The details of cultivable lands turning to fallow lands and the yield decline of crops are presented in Table 6. In the case of cultivable lands turning to fallow, the higher impact was noticed in seriously affected farms with 1.25 hectares and 1.05 hectares of fallow land and 9.95 and 8.56 years of fallow in Avaniyapuram and Sakkimangalam study area respectively. Low affected farms registered less fallow area with 0.40 hectares and 0.45 hectares and the years of fallow were less with 5.25 years and 4.23 years in Avaniyapuram and Sakkimangalam study area respectively. This scenario leads to the conclusion that sewage pollution led to fallow lands and the increase in pollution intensity had influenced the increased fallow lands.

In paddy crop, the highest yield decline was observed in seriously affected farms with 2.25 tonne per hectare in Avaniyapuram area and 2.05 tonne per hectare in Sakkimangalam area. In low affected farms, the said decline in yield was lower with 1.05 tonne per hectare in Avaniyapuram area and 0.98 tonne per hectare in Sakkimangalam area. Likewise, in Maize crop, the yield decline was observed in seriously affected farms with 22.30 tonne per hectare in Avaniyapuram area and 19.30 tonne per hectare in Sakkimangalam area. In low affected farms, the said decline in yield was lower with 15.35 tonne per hectare in Avaniyapuram area and 14.62 tonne per hectare in Sakkimangalam area. Thus it could be concluded from the table that

sewage pollution led to increased fallow area, increase years of fallow, increased yield decline. Sewage pollution was the only factor that influenced these externalities in both categories of affected farms as opined by the respondents.

Averting or defensive expenditure for land

The details of land based averting or defensive expenditure of both Avaniyapuram and Sakkimangalam study areas are presented in Table 7. It could be seen from the table that these expenditures were higher in seriously affected farms with Rs. 16500 and Rs. 15000 per hectare in Avaniyapuram and Sakkimangalam study areas respectively and for low affected farms, it was lower with Rs.10200 and Rs.9250 per hectare in Avaniyapuram and Sakkimangalam study area respectively.

The composition of these land based expenditure revealed that for the item of expenditure on organic manures, the affected farmers incurred the highest expenditure and it was 72.73 per cent and 78.43 per cent to total in Avaniyapuram study area for seriously affected and low affected farmers respectively. The said expenditure was 75.00 per cent and 81.08 per cent to total in Sakkimangalam study area for seriously affected and low affected farmers respectively.

Next, the highest expenditure was incurred on additional seed for crop and it was 21.21 per cent and 14.71 per cent to total in Avaniyapuram study area for seriously affected and low affected farmers respectively. The said expenditure was 20.00 per cent and 13.51 per cent to total in Sakkimangalam study area for seriously affected and low affected farmers respectively

The quantum of gypsum application even though marginal but it was directly proportional to the pollution intensity in affected farms. Thus it could be concluded from these analyses that incurring the averting expenditure for land was directly related to the pollution intensity prevailed in these farms and organic manure application was the highest land based averting expenditure.

Decline in land value

The details of land value in sample farms are presented in Table 8. It could be seen from the table that the highest land value of Rs. 3065134 and Rs. 2954785 per hectare was observed in non-affected farms of Avaniyapuram and Sakkimangalam study area respectively. The declines increased from low affected farms to seriously affected farms and in Avaniyapuram study area, it was 30.34 per cent and 58.99 per cent respectively. In Sakkimangalam study area, the decline in land value was 34.43 per cent 60.54 per cent respectively from low affected farms to seriously affected farms. Thus there was reduction in land value across affected lands as one could expect. The decline in land value further had a direct relationship with increase in pollution intensity.

Water Quality Deterioration

The details of water quality in the two categories of affected farms of serious and low of in both Avaniyapuram and Sakkimangalam study areas are presented in Table 9. Water quality was assessed by observing the quality characteristics of water in the affected farms and also through personal enquiry with farmers. Water quality index was developed in a three point scale of one for poor quality, two for average quality and three for good quality for each of the

quality characteristics of taste, softness and healthiness and the combined effect formed the said index. This index was developed separately for rainy and dry seasons to examine the observed changes caused by the dilution of acids due to rainy water in rainy season.

It could be seen from the table that the water quality got worsened as the pollution intensity had increased. Also, the rainy season water quality had shown a worse situation as compared to dry season for all the three water quality parameters in all the two categories of affected farms due to more concentration of sewage because of the absence of dilution effects and also due to comparatively lesser water availability.

Averting or defensive expenditure on water

The details of averting or defensive expenditure made on water for irrigation and drinking purposes of both Avaniyapuram and Sakkimangalam farms are presented in Table 10. In the case of averting expenditure on water which included both irrigation and drinking water, the total averting or defensive expenditure was higher in seriously affected farms (Rs.2861 and Rs.2654 per family) in Avaniyapuram and Sakkimangalam study area respectively followed by low affected farms (Rs.1756 and Rs. 1701 per family) in Avaniyapuram and Sakkimangalam study area respectively which showed the direct relationship of this expenditure with pollution intensity. Thus the averting expenditure for irrigation water increased with increase in pollution intensity.

It could also be seen from the table that averting or defensive expenditure for drinking water included obtaining protected water, getting water from non-polluted areas, boiling the water and purchase of water filters. The analysis of averting or defensive expenditure for drinking water revealed that the seriously affected farmers incurred more expenditure in getting water from non-polluted areas (29.71 per cent and 30.14 per cent to total expenditure in this category in Avaniyapuram and Sakkimangalam study area respectively), followed by making boiled water (15.94 per cent and 16.05 per cent in Avaniyapuram and Sakkimangalam study area respectively) and thirdly with purchase of water filters (15.73 per cent and 15.15 per cent in Avaniyapuram and Sakkimangalam study area respectively). The low affected farmers expended more with 34.17 per cent and 34.10 per cent in Avaniyapuram and Sakkimangalam study area respectively in getting water from non-polluted areas followed by purchase of water filters with 14.58 per cent and 14.46 per cent in Avaniyapuram and Sakkimangalam study area respectively and thirdly in making boiled water with 11.39 per cent and 12.35 per cent in Avaniyapuram and Sakkimangalam study area respectively to the total expenditure. Thus, it could be concluded from the above discussion that the affected farmers expended more in getting water from non-polluted areas followed by boiling water and purchase of water filters and also the said expenditure increased with increase in pollution intensity.

Externalities on Human Health

The externalities of sewage pollution on human health, namely skin and lung diseases and common health diseases of dysentery, fever and itches are given in Table 11.The incidence of health disorders was higher in seriously affected farms with 87.56 per cent and 86.23 per cent in Avaniyapuram and Sakkimangalam study

area respectively followed by low affected farms with 75.17 per cent and 69.13 per cent in Avaniyapuram and Sakkimangalam study area respectively. The intensity (the number of individuals affected and number of times affected) of both skin and lung diseases was lower in low affected farms and was higher in seriously affected farms. As compared to skin and lung diseases, the intensity of common diseases was very much high in both categories which might be due to the effect of sewage pollution and public hygiene due to stagnation.

The severity of common diseases occurred in their households were elicited from farmers respondents by making them to rank the severity from high to no incidence. The analysis on severity of common diseases revealed that the proportion of highly severe (55.32 % and 55.60% in Avaniyapuram and Sakkimangalam study area) was high in seriously affected farms.

On the other hand, in low affected farms, the moderate incidences was high (45.62 % and 39.65 % in Avaniyapuram and Sakkimangalam study area) followed by less severe (33.20% and 38.26% in Avaniyapuram and Sakkimangalam study area) incidences respectively. These results indicated that severity of common diseases varied directly with pollution intensity. The averting or defensive expenditure incurred for recovery from skin and lung diseases and also common diseases exhibited increasing trend from low affected to seriously affected farms.

Treatment cost formed more than 75 per cent of total cost for recovery of skin and lung diseases and common diseases. Thus it could be seen from the table that the family wise incidence of health disorders, intensity of skin and lung diseases, severity of common diseases and averting or defensive expenditure for human health amelioration increased with increase in pollution intensity.

Externalities on animal health

The externalities of sewage pollution on animal health, namely milk decline and cattle diseases are presented in Table 12. It could be seen from the table, that even though the proportion of feeding with farm produces was lower in seriously affected farms (65.37% and 62.33%) in Avaniyapuram and Sakkimangalam study area respectively, the milk decline in cattle (18.13% and 17.26 % in Avaniyapuram and Sakkimangalam study area respectively) and the incidence of cattle diseases (45.83% and 48.17% in Avaniyapuram and Sakkimangalam study area respectively) were highest in severely affected farms , due to prevailing high intensity of pollution in these farms.

In low affected farms, the milk decline in cattle (7.83% and 8.52 % in Avaniyapuram and Sakkimangalam study area respectively) and the incidence of cattle diseases (22.16% and 24.25% in Avaniyapuram and Sakkimangalam study area respectively) was lower. The averting or defensive expenditure to ameliorate the animal health impairment in seriously affected farms was Rs. 250.63 and Rs.285.32 in Avaniyapuram and Sakkimangalam study area respectively and in low affected farms, it was Rs.150.36 and Rs.163.05 in Avaniyapuram and Sakkimangalam study area respectively.

It could be seen that all the externalities of sewage pollution on animal health, namely milk decline, cattle diseases and defensive or averting expenditure for animal health increased with increase in pollution intensity.

Table.1 Electrical conductivity of irrigation water of study area

Class	Villages		Criteria	Classification
	Unit 1	Unit 2	EC (ds/m)	
I	Avaniyapuram	Sakkimangalam	7.50	Seriously affected
II	Kaluvangulam	Elamanur	2.00	Low affected
III	Paraipatty	Nedungkulam	0.60	Non affected

Source: Department of Agriculture- Avaniyapuram & Sakkimangalam- Madurai district 2015.

Table.2 Cropping pattern in sample farms (in hectares)

Sl.No	Crops	Avaniyapuram			Sakkimangalam		
		Serious	Low	Non-affected	Serious	Low	Non-affected
1.	Paddy	19.20	26.13	32.66	17.60	24.46	30.72
2.	Maize	3.67	4.15	5.87	3.08	3.96	5.18
3.	Sugarcane	0.00	15.08	30.96	0.00	14.68	28.03
4.	Vegetables	1.02	2.14	4.16	1.15	2.23	4.02
5.	Fodder grass	0.96	1.56	1.68	0.87	1.44	1.96
	Total	**24.85**	**49.06**	**75.33**	**22.7**	**46.77**	**69.91**

Table.3 Gross crop income in sample farms (in rupees per hectare)

Sl.No	Particulars	Income	
		Avaniyapuram	Sakkimangalam
1.	Serious	116814	105765
2.	Low	188537	165432
3.	Non-affected	256786	215312

Table.4 Average gross income in sample farms (in rupees per farm)

S.No.	Source	Avaniyapuram			Sakkimangalam		
		Serious	Low	Non-affected	Serious	Low	Non-affected
1.	Crop	82500 (77.06)	125537 (90.58)	168786 (94.37)	79568 (76.89)	115268 (89.38)	155645 (93.95)
2.	Animal husbandry	19562 (18.27)	9563 (6.90)	7562 (4.23)	18412 (17.19)	10451 (8.10)	7381 (4.46)
3.	Non-farm income	5000 (4.67)	3500 (2.53)	2500 (1.40)	5500 (5.32)	3250 (2.52)	2650 (1.60)
4.	Total gross income	107062 (100.00)	138600 (100.00)	178848 (100.00)	103480 (100.00)	128969 (100.00)	165676 (100.00)

Table.5 Land quality and soil testing in affected farms

Sl.No	Particulars	Avaniyapuram		Sakkimangalam	
		Serious	Low	Serious	Low
I	**Land quality**				
1.	Poor	94.29	31.43	88.57	37.14
2.	Average	5.71	45.71	11.43	42.86
3.	Good	-	22.86	-	20.00
II.	**Soil testing**	65.71	28.57	54.29	45.71

Table.6 Fallow lands and yield decline in affected farms

Sl.No	Particulars	Avaniyapuram		Sakkimangalam	
		Serious	Low	Serious	Low
1.	**Fallow lands**				
a.	Area (in ha)	1.25	0.45	1.05	0.40
b.	Years of fallow	9.95	5.25	8.56	4.23
2.	**Yield decline**				
a.	Quantity				
	Paddy (T/ha)	2.25	1.05	2.05	0.98
	Maize (T/ha)	22.30	15.35	19.30	14.62
b.	Reasons (in %)				
	Sewage pollution	100.00	100.00	100.00	100.00
	Drought	-	-	-	-
	Pest and diseases	-	-	-	-

Table.7 Averting or defensive expenditure for land (in rupees per hectare)

Sl.No	Averting or defensive expenditure	Avaniyapuram		Sakkimangalam	
		Serious	Low	Serious	Low
1.	Additional seed for crops	3500 (21.21)	1500 (14.71)	3000 (20.00)	1250 (13.51)
2.	Organic manure	12000 (72.73)	8000 (78.43)	10500 (75.00)	7500 (81.08)
3.	Gypsum	1000 (6.06)	700 (6.86)	1500 (10.00)	500 (5.41)
	Total	16500 (100.00)	10200 (100.00)	15000 (100.00)	9250 (100.00)

Table.8 Land value across sample farms
(in rupees per hectare)

Sl.No	Category	Land value	
		Avaniyapuram	**Sakkimangalam**
1.	Serious	1256874	1165894
2.	Low	2135124	1937458
3.	Non –affected	3065134	2954785

Table.9 Water quality in affected farms (in %)

Sl.No	Particulars	Avaniyapuram		Sakkimangalam	
		Serious	**Low**	**Serious**	**Low**
1.	**Taste**				
a.	**Rainy season**				
i	Poor	97.14	31.43	88.57	-
ii	Average	2.86	54.29	11.43	65.71
iii	Good	-	14.29	-	34.29
b.	**Dry season**				
i	Poor	65.71	45.71	62.86	40.00
ii	Average	34.29	31.43	37.14	31.43
iii	Good	-	22.86	-	28.57
2.	**Softness**				
a.	**Rainy season**				
i	Poor	62.86	42.86	57.14	37.14
ii	Average	37.14	40.00	40.00	51.43
iii	Good	-	17.14	2.86	11.43
b.	**Dry season**				
i	Poor	54.29	17.14	51.43	37.14
ii	Average	45.71	34.29	48.57	42.86
iii	Good	-	48.57	-	20.00
3.	**Healthiness**				
a.	**Rainy season**				
i	Poor	74.29	17.14	68.57	20.00
ii	Average	25.71	54.29	31.43	57.14
iii	Good	-	28.57	-	22.86
b.	**Dry season**				
i	Poor	65.71	20.00	62.86	25.71
ii	Average	34.29	54.29	37.14	45.71
Iii	Good	-	25.71	-	28.57

Table.10 Averting or defensive expenditure on irrigation and drinking water (Rs./ family)

Sl.No	Particulars	Avaniyapuram		Sakkimangalam	
		Serious	Low	Serious	Low
I	**Irrigation water -** using Gypsum	755 (26.39)	550 (31.32)	700 (26.38)	500 (29.39)
II	**Drinking Water**				
I	Expenditure involved in getting protected water.	350 (12.23)	150 (8.54)	326 (12.28)	165 (9.70)
Ii	Boiling water	456 (15.94)	200 (11.39)	426 (16.05)	210 (12.35)
Iii	Water filters	450 (15.73)	256 (14.58)	402 (15.15)	246 (14.46)
iv	Expenditure involved in getting water from non-polluted areas	850 (29.71)	600 (34.17)	800 (30.14)	580 (34.10)
	Total	2861 (100.00)	1756 (100.00)	2654 (100.00)	1701 (100.00)

(Figures in parentheses indicate per cent to total)

Table.11 Externalities on Human Health

Sl.No	Particulars	Avaniyapuram		Sakkimangalam	
		Serious	Low	Serious	Low
1.	Incidence of health disorders family wise (%)	87.56	75.17	86.23	69.13
2.	Intensity (No.)	3.16	2.03	3.65	2.25
3.	Averting or defensive Expenditure				
I	Physician cost(Rs)	125.00 (20.00)	85.00 (22.08)	115.00 (20.35)	75.60 (33.51)
Ii	Treatment cost(Rs)	500.00 (80.00)	300.00 (77.92)	450.00 (79.65)	150.00 (66.49)
5.	Total (Rs)	625.00 (100.00)	385.00 (100.00)	565.00 (100.00)	225.60 (100.00)
6.	Common disease				
7.	Intensity (no.)	25.00	12.00	22.00	10.00
8.	Severity(%)				
I	High	55.32	12.00	56.60	15.00
ii	Moderate	35.12	45.62	33.65	39.65
iii	Low	9.56	33.20	9.75	38.26
iv	No	-	9.18		7.09
9.	Averting or defensive expenditure				
I	Physician cost (Rs)	135.26 (25.27)	95.18 (27.57)	125.03 (21.75)	85.32 (23.68)
Ii	Treatment cost(Rs)	400.00 (74.73)	250.00 (72.43)	450.00 (78.25)	275.00 (76.32)
10.	Total (Rs)	535.26 (100.00)	345.18 (100.00)	575.03 (100.00)	360.32 (100.00)

Table.12 Externalities on animal health

Sl.No	Particulars	Avaniyapuram		Sakkimangalam	
		Serious	Low	Serious	Low
1.	Feeding with farm produces (%)	65.37	89.67	62.33	85.62
2.	Milk decline in cattle (%)	18.13	7.83	17.26	8.52
3.	Cattle diseases				
a.	Incidence (%)	45.83	22.16	48.17	24.25
b.	Intensity (No)	1.96	1.22	1.85	1.13
c.	Averting or defensive expenditure				
4	Treatment cost (Rs)	250.63	150.36	285.32	163.05

Table.13 Externalities on socio-economic condition of farmers

Sl.No	Particulars	Avaniyapuram		Sakkimangalam	
		Serious	Low	Serious	Low
1.	Land selling				
a.	Number of farmers (%)	52.31	22.25	56.31	20.30
b.	Extent (ha)	1.56	0.65	1.42	0.55
c.	Reasons (%)				
i.	Sewage pollution	92.50	72.31	88.90	66.35
ii.	Sewage pollution and poor economic conditions	7.50	27.69	11.10	33.65
2.	Migration of family members				
a.	Number of families (%)	38.12	19.35	45.23	21.78
b.	Occupation				
	Business	22.31	16.35	38.56	31.65
	Others	77.69	83.65	61.44	68.35

Externalities on socio-economic conditions

The externalities of sewage pollution on socio-economic consequences of farmers in affected areas such as land selling and migration of family members are presented in Table 13. It could be seen from the table that the land selling by affected farmers was higher with 52.31 per cent and 56.31 per cent in seriously affected farms in Avaniyapuram and Sakkimangalam study area respectively and it was lower in 22.25 per cent and 20.30 per cent in low affected farms in Avaniyapuram and Sakkimangalam study area respectively. This land selling was coincided with the intensity of pollution prevailed in these farms. The extent of land selling had also exhibited similar pattern with 1.56 hectares and 1.42 hectares in seriously affected farms in Avaniyapuram and Sakkimangalam study area respectively and it was, 0.65 hectares and 0.55 hectares in low affected farms in Avaniyapuram and Sakkimangalam study area respectively.

Land selling due to sewage pollution alone was highest in seriously affected farms

(92.50 per cent and 88.90 per cent in Avaniyapuram and Sakkimangalam study area respectively) as compared to (72.31 per cent and 66.35 per cent in Avaniyapuram and Sakkimangalam study area respectively) in low affected farms. On the other hand, land selling due to both sewage pollution and poor economic conditions was higher in low affected farms with 33.65 per cent and 27.69 per cent in Avaniyapuram and Sakkimangalam study area respectively as compared to 7.50 per cent and 11.10 per cent in seriously affected farms in Avaniyapuram and Sakkimangalam study area respectively. Hence sewage pollution influenced the land selling in seriously affected farms whereas in low affected farms, sewage pollution and poor economic conditions influenced the land selling.

Migration of family members were higher in seriously affected farms with 38.12 per cent and 45.23 per cent in Avaniyapuram and Sakkimangalam study area respectively and it was lower with 19.35 per cent and 21.78 per cent in low affected farms in Avaniyapuram and Sakkimangalam study area respectively. Migrated family members engaged more in other local occupations like teaching, lorry driving, construction work and in textile industry rather than doing business. The proportion of this occupation in seriously affected farms was 77.69 per cent and 61.44 per cent in Avaniyapuram and Sakkimangalam study area respectively and 83.65 per cent and 68.35 per cent in low affected farms in Avaniyapuram and Sakkimangalam study area respectively.

Conclusion

The sewage pollution caused decline in crop area in paddy, sugarcane, maize, vegetables and fodder grass in affected farms and also the decline in cropped area was increased with increase in pollution intensity. In seriously affected farms, decline in crop income was 54.51 per cent and 50.88 per cent in Avaniyapuram and Sakkimangalam study area respectively. In low affected farms, the said decline was 26.58 per cent and 23.17 per cent in Avaniyapuram and Sakkimangalam study area respectively. To compensate the income loss due to sewage pollution, the seriously and low affected farmers engaged actively in animal husbandry and non-farm activities.The poor land quality was higher in seriously affected farms with a proportion of 95.00 per cent and 87.50 per cent and the average land quality was higher in low affected farms 45.00 per cent and 42.35 per cent of Avaniyapuram and Sakkimangalam study area respectively. The fallow lands were higher in seriously affected farms with 1.25 and 1.05 hectares followed by low affected farms with 0.45 and 0.40 hectares in Avaniyapuram and Sakkimangalam study area respectively. The yield decline for crops of paddy, sugarcane and maize had coincided with pollution intensity prevailed in affected farms. Sewage pollution was the only factor that influenced these externalities in both categories of affected farms. The incurring of averting expenditure for land was directly related to the pollution intensity prevailed in these farms and organic manure application was the highest land based averting expenditure.

The water quality got worsened as the pollution intensity increased. Also, the rainy season water quality had shown a worse situation as compared to dry season for all the three water quality parameters in all the two categories of affected farms due to absence of dilution effects and also due to comparatively lesser water availability. The averting or defensive expenditure for drinking water and irrigation water included obtaining protected water, getting water from non-polluted areas, boiling the water and purchase of water filters. This

expenditure was higher in seriously affected farms followed by low affected farms in study areas which showed the direct relationship of this expenditure with pollution intensity.

The externalities of sewage pollution on human health included skin and lung diseases and common health diseases of dysentery, fever and itches. The incidence of health disorders was higher in seriously affected farms with 87.56 per cent and 86.23 per cent in Avaniyapuram and Sakkimangalam study area respectively followed by low affected farms with 75.17 per cent and 69.13 per cent in Avaniyapuram and Sakkimangalam study area respectively. Treatment cost formed more than 75 per cent of total cost for recovery of skin and lung diseases and common diseases. Thus the family wise incidence of health disorders, intensity of skin and lung diseases, severity of common diseases and averting or defensive expenditure for human health amelioration increased with increase in pollution intensity.

Milk decline, cattle diseases and defensive or averting expenditure for animal health increased with increase in pollution intensity. Land selling by affected farmers was higher with 52.31 per cent and 56.31 per cent in seriously affected farms in Avaniyapuram and Sakkimangalam study area respectively and it was lower in 22.25 per cent and 20.30 per cent in low affected farms in Avaniyapuram and Sakkimangalam study area respectively. Thus land selling and extent of land selling was coincided with the intensity of pollution prevailed in these farms. Migrated family members engaged more in other local occupations like teaching, lorry driving, construction work and in textile industry rather than doing business.

Policy implications

The study revealed that the sewage pollution resulted in decline in crop area, increased fallow lands and yield decline, decline in crop income, decline in land value and increased averting or defensive expenditure for land, irrigation water, drinking water, human and animal health in affected farms. In addition, the study also found that the sewage pollution led to increased socio-economic consequences of land selling and migration. These externalities due to sewage pollution was greatly influenced by the pollution intensity prevailed in affected lands. Thus the solution to the sewage pollution problem should consider the intensity of these externalities and hence appropriate strategies like proper functioning of Sewage Treatment Plants with recycling should be attempted.

The local soil amendments like organic manure and gypsum are very efficient in tackling sewage pollution and hence the extension infrastructure of Agriculture Department should motivate the farmers to apply increasingly these amendments by conducting awareness campaigns and demonstrations.

The study revealed that the human health disorders of skin and lung diseases and common health disorders, milk decline in cattle and cattle diseases are more prevalent in the study area. Hence the health infrastructure of the region should be further strengthened to meet this increasing human and animal health disorders due to sewage pollution.

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How to cite this article:

Amarnath, J.S., and Sridevi, U. 2016. Externalities of Sewage Pollution in Madurai District of Tamil Nadu, India. *Int.J.Curr.Res.Aca.Rev.*4(8): 183-197.
doi: http://dx.doi.org/10.20546/ijcrar.2016.408.015