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Depletion of water quality and quantity in Kuttanad, Kerala

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The major occupation of rural people in Alleppey district is agriculture and fishing. These activities demand water which is made available from network of canals and rivers in this region. Apart from this, the well-knit network of canal is used for inland navigation and daily water requirement of the local people. However, many distribution channels are being blocked by filling mud or local materials for construction of road. With the blockade in flow of water and decreasing use of waterways the water stagnation and pollution is reported in many canals. Thus canals away from the main waterways are clogged with hyacinth and weeds. This is degrading the water quality leading to scarcity of potable water in vicinity. The environmental problem such as bacteriological pollution, anaerobic conditions and eutrophication is impacting the health conditions of people, water-borne disease being more prevalent. Also, it is hindering inland navigation and affecting the water tourism.

The study focuses on the depletion of water bodies and how it has led to the declining trend in agriculture in Alleppey region. The water samples are collected from canals and rivers of the region and it is tested for various water quality parameters. An analysis is done on the degradation of the water quality. Further, the consequences of poor water quality are studied and suggestions are made for restoring its quality.

Keywords: Water resource, Inland waterways, Canal, Water quality, Alleppey

INTRODUCTION

The quality of water influences our lives in many ways more than just drinking. The physio-chemical parameters of water used for domestic purposes like cooking, washing, bathingand irrigation purposes have a direct or indirect impact on health condition of people (Khan & Srivastava 2012). The human intervention and increased development often led to the poor surface water flow and increased concentration of pollutants in aquatic body (Cao 1989). The daily requirement of water is served from various sources like well, tapping ground water, and inland canals.

In areas with well-knit network of rivers and canals, the water in these water bodies is used for agriculture and other domestic activities apart from navigation. The inland water ways are one of the very prominent means of transport in such areas (Sriraman 2009 and Rangaraj & Raghuram 2007). However, in some region the canals are being blocked because of mud fillings done during construction of road. This causes growth of hyacinth and weeds and degradation of water quality in stagnant water bodies. In addition to it the waste water the domestic houses contribute a lot in the organic content of the water bodies (NEPA 1996). The growth of aquatic weeds, algal blooms and other aquatic microorganism get triggered with the augmented organic content, responsible to a poor water quality to a great deal (Carmichael, 1992 & 1994, Gopalan 1981). The excessive growth of weeds is also responsible for secretion of various toxins making the water unfit for the domestic use (Harada et al., 1996). The study of quality of water and its far reaching consequences is stated through this paper.

Good quality of water has the potential to maximize yield of agriculture. With poor quality of water, problems like salinity, soil contamination has to be dealt with. Contaminated water can act as breeding places and can encourage the growth of bacteria leading to water borne diseases. Degraded water quality at many places becomes a ground of many water borne diseases and epidemics (World Bank 1992 & Meinhardt 2002). Being the home of remarkable water bodies and unique ecosystem there is a drastic need to save the Kuttanad region (Thampatti & Padmakumar1999, Sabu etal. 2001 and Alexander et al. 2010). With the growing urbanization and human impact the Kuttanad region has been under severe and ever-increasing threat. Due to which the flora and fauna as well as the livelihood of the people of Kuttanad have seriously and negatively affected. There is a

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significant loss of fish population affecting the socio-economic life of local people. The eutrophic water bodies have aggravated the leaching of nitrate and phosphate resulting into high level of pollution with organic, inorganic and toxic components. The situation has become worse with the poor drainage system due to stagnant and blocked water ways. The crisis of potable water and emergence of water borne parasites and diseases have made the region more susceptible to poor quality of life. However, various mitigation strategies were planned time to time to cope up with the socio-economical and environmental crisis in Kuttanad (Swaminathan, 2007). Sustainable water management like effective rainwater harvesting systems in Kuttanad would also solve the problems associated with water to some extent (Christina Tang 2009).

This study gives an insight about the quality of water in a small region of Allepey district of Kerala and its effects on local people. An attempt has been made to analyse the cause of degrading water quality and provide possible solutions to restore the water quality which can lead to sustainable development.

Study Region

Alleppeyalso known as Alappuzha is one of the 14 districts of Kerala which is known for well-knit networks of rivers, canal and backwaters. The Kuttanad region characterized by a low-lying land measuring about 25 km east-west and 60 km north-south on the west coast of Kerala (Census, 2001). This boundary is spread over the three districts of Alappuzha, Kottayam, and Pathanamthitta (Kurein 1978). In another study it has been reported that the boundaries of Kuttanad is not distinctly defined and is redefined several times, today it is comprised of 79 revenue villages, 10 Taluks and 3 Districts (Dwivedi, 2011).

Alleppey district is a major part of Kuttanad region which is well known for vast paddy fields and geographical peculiarities. The farming is carried out below sea level in Kuttanad region. Rapid modernization with less focus on sustainable development is creating an imbalance in the intricate ecosystem of this region. Three of its large lagoons, Vembanad, Ashtamudi and Shasthanamkota, have been declared Ramsar sites, wetlands of environmental significance. Engineers and contractors have done the most damage to network of inland canals and water bodies, cheered on by local residents looking for a shortcut to modernity.

Till 1970s farmers used to have only one crop a year, but with the introduction of new fertilizers and pesticides and also by constructing barrage (bund), that would cease the saline water, farmers successfully enacted the plan of two crops a year. The farmer enthusiastically embraced a two-crop regime and pumped in the prescribed quantum of chemical inputs into their fields, and flushed these toxic contaminants into the river system. According to the department of agriculture, Kuttanad uses twice the amount of pesticides per tonne of rice than the rest of the state. The overuse of pesticides has altered the nutrient parameters of soil affecting the agricultural yield and will risk the life of local community. Studies have reported that pesticides have emerged as one of the biggest risk to human life. Health ailments like skin allergy and headache were quite prominent in Kuttanad region. (Dinham 1993, Rakhesh 1999, Krishna 2001 & Indira 2007). As time progressed, farm incomes declined and development in educational sector led to changes in Kuttanad's employment sector.

The recent studies indicate that the larger percentage of local people in Kuttanad region have shifted their occupation from the past natural choice of occupation as farming and fishing which were entirely dependent on water. Although in recent past it has been observed that with the increased intrusion of human into the backwater of Kuttanad there is the significant decline in the fish population (Nair 1991). The ever increased dumping of industrial, agricultural and domestic waste into the backwater has significantly damaged the aquatic life of Kuttanad region (Gopalan 1981 & Devalatha 1994). This shift needs an investigation. Many water ways are now covered with hyacinths and is not advisable for domestic uses and is rarely available for local transportation. Extensive construction of roads has resulted in increased bus services and boat services gradually decreased. Roads were constructed over river and canal beds affecting the water flow. Roads have increased the monetary value of the land. More and more people supported the construction of roads even when the basic conditions were violated. Ignorance towards sustainable development has thus resulted in the present condition of depleting and stagnant water bodies in Kuttanad (Meera & Nandan 2010).

Canals and tributaries away from the main rivers are clogged with hyacinth and weeds. People who are engaged in the traditional activities of farming and fishing are in trouble. Clogging and pollution have also made the canals useless for many other domestic purposes. Consumption patterns have altered and people throw plastics and non-biodegradable waste into the water. The solid waste dumped into the water 15 years ago was organic and therefore did not have the same impact. All these factors contributed to the degrading quality of stagnant water bodies which has become a breeding place for most of the parasites causing severe health problems. The raised river bed too has affected flow, with two monsoons a year adding about 3,000 mm annually, 38 rivers generously flowing through it, and over 1,500 km of waterways afforded by the lagoon, lakes, estuary, rivers and canals, water that does not flow properly is a serious problem. What remains are the famed houseboats, the boat races, the idyllic waters, the emerald green paddy fields, the carelessly strewn banana plants attract tourists who laze on boat decks.

Study area in focus

To study the water quality parameters Alleppey-Changanacherry canal is selected. According to a report by Padmakumar, B. in 2010, 70% of the total waterborne diseases in Alleppey is diagnosedin thepeople residing in vicinity of this canal. More than 500 families reside along the banks of the canal and are directly or indirectly affected by the degrading water quality of the canal. The canal is used intensively for agricultural purposes. Along the canal, there is a road which connects two districts. This has led to decreased attention of government towards maintenance of the canal.

Methodology

Water samples were collected from 10 different sites in the study area of which 4 samples were taken from flowing water and 6 samples were taken from stagnant water. Figure 1 shows 8 sample collection site, flowing water sites are marked in yellow colour and stagnant water sites are marked in red colour. Water samples were collected from the surface of canals and tributaries. The samples have been collected from boat jetty and along the road, closer to the bank depending upon the existence of jetties. The samples were collected in pre-cleaned polythene bottles and were packed intact for transportation to the laboratory in Noida. The geographical coordinates of sampling sites were found using a Garmin GPS tracker. Table 1 provides the details of sample collection sites and Figure 2 displays the collected water sample. Flowing water samples are named as F1, F2, F3, F4 and stagnant water samples are designated as S1, S2, S3, S4, S5 and S6.

Water samples were tested for various physio-chemical parameters like temperature, turbidity, colour, pH, total dissolved solids, dissolved oxygen, alkanity, nitrate and phosphate (Khan & Srivastava 2012). To understand the extent of biological contamination and source of many water borne diseases, E. coli test was conducted. To study the variation in the groundwater level and quality of the study area in focus, data was acquired from Central Groundwater Board (CGWB).

Figure I: Study area in focus with water sampling sites (source: Google earth)

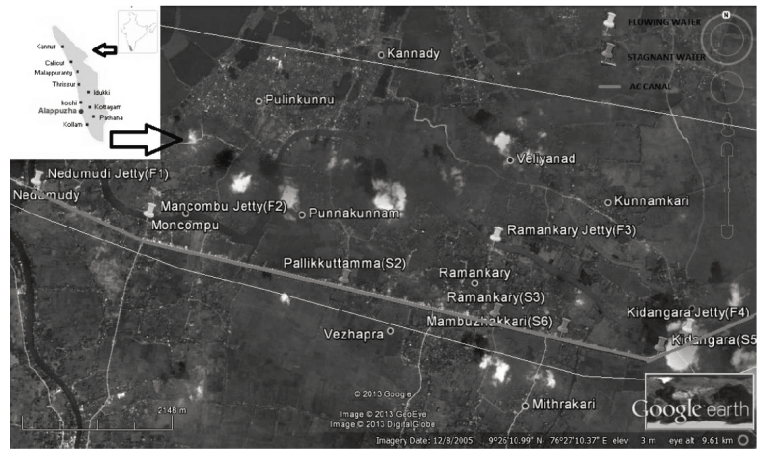


Table I. Geographical coordinates of water sampling sites

PLACE	STATION	LATITUDE	LONGITUDE
NEDUMUDI JETTY	F1	9° 26' 35"	76° 24' 18"
MANCOMBU JETTY	F2	9° 26' 17"	76° 25' 14"
RAMANKARY JETTY	F3	9° 25' 59"	76° 28' 3"
KIDANGARA JETTY	F4	9° 25' 13"	76° 29 '33"
ALAPPUZHA BOAT JETTY	S1	9° 30' 3"	76° 20' 43"
PALLIKKUTTAMMA	S2	9° 25' 42"	76° 26' 49"
RAMANKARY	S3	9 °25' 23"	76 °28' 1"
MANAKKACHRA	S4	9° 26'	76° 32' 6"
KIDANDARA	S5	9° 25' 5"	76° 29' 19"
MAMBUZHAKKARI	S6	9 °25' 15"	76° 28' 32"

Figure II. Water samples collected from sampling sites.

Results and Discussions

Water Quality of Surface water

The physio-chemical parameters of water quality was tested for samples collected from flowing water and stagnant water and the values of these parameters were compared. The physical parameters collected for the samples were temperature, turbidity and colour. The chemical properties of water samples like pH, total alkalinity, dissolved oxygen, total hardness; nitrate and phosphate were tested in laboratory. The results are tabulated in Table 2. The bar chart in Figure 4 shows the comparison of average values of chemical properties of water samples collected from sites with flowing water and stagnant water respectively.

Most of the values of water samples are well within the permissible limits of drinking water provided by Bureau of Indian Standards (BIS: IS 105000) and Central Pollution Control Board (CPCB). However, considerable degradation of water quality is observed in the stagnant water samples as compared to flowing water samples.

Temperature

The temperature ranges from 26 to 33 Degree Celsius. The water samples F3, S2, S3, S4, S5, and S6 were collected at around 4 pm and the rest of the samples were collected at noon time, the next day. The temperature is close to the average temperature of 33 Degree Celsius in Alleppey district. The temperature is crucial as dissolved oxygen levels decrease with increase in temperature.

Turbidity

Turbidity of water samples were categorised as less, medium and high. Water samples collected from flowing water had less turbidity, whereas the samples collected from stagnant water had high turbidity. The amount of undissolved minerals and waste products dumped into the water bodies contribute to the high turbidity.

Colour

The water samples collected from the flowing water were colourless. Samples S1and S6 was little brownish clearly illustrating the degrading water quality and the lack of decomposition of wastes dumped into it. Sample S1 which was collected from Alleppey boat jetty outside the study region in focus showed dirty yellow colour. The outlets provided in Alleppey boat jetty are inadequate when compared to the number of boats parked in the station. The obstruction caused in the flow of water affects the quality of water.

Potential of Hydrogen (pH)

The pH values of water collected from stagnant water is slightly acidic and is falling out of the potable water standards. On the other hand, the water samples collected from flowing water is found to be within the limits of various standards issued by BIS and WHO. The slight acidity of the water samples S2, S3, S4, S5 and S6 is explained by the leaching effect of soils from agricultural fields, mainly paddy. The effect of leachates on the flowing water is temporary since the self-purification process of water regenerates its original quality.

Table II. Results of water quality tests

STATION	TEMPERATURE (° C)	TURBIDITY	COLOUR	pH	TOTAL ALKALINITY (mg/L)	DISSOLVED OXYGEN (mg/L)	TOTAL HARDNESS (mg/L)	NITRATE (mg/L)	PHOSPHATE (mg/L)
F1	31	medium	Colourless	6.15	40	4.48	57.14	1.32	0.04
F2	31	less	Colourless	6.47	20	5.04	42.85	2.4	0.08
F3	26	less	Colourless	6.41	30	5.6	32.14	1.62	0.06
F4	31	less	Colourless	6.33	20	5.2	50	2.5	0.01
S1	33	medium	Dirty yellow	7.06	70	2.32	285.71	28.5	9.4
S2	27	high	Pale yellow	6.03	40	3.6	82.14	17.6	5.4
S3	27	high	Colourless	6.09	10	3.84	85.17	18.4	6.6
S4	27	high	Colourless	6.08	20	3.2	121.42	22.4	8.5
S5	27	high	Colourless	5.64	20	3.52	78.57	23.5	8.8
S6	26	high	Pale brown	5.61	30	3.68	89.28	20.6	7.9

Alkalinity

The Total alkalinity of water samples was very low. There wasn't much variation between the flowing and stagnant water samples for alkalinity. The low values show the absence of carbonates and hydroxides in the water samples. Only bicarbonates are present in the water collected, thus the ability to neutralise acidity of these water samples is very low. Alkalinity of sample S1 was found to be relatively high when compared to the other samples.

Dissolved Oxygen (DO)

The Dissolved oxygen level for stagnant water was found to be about 3mg/l. Meanwhile, the water samples collected from flowing water samples had DO of 5mg/l. The dissolved oxygen levels for stagnant water is very low as the minimum DO content for the survival of fish is 4mg/l. As mentioned earlier the water after irrigation activities are pumped back into the AC canal, thus the water is rich in pesticides and fertilizers. The nutrient rich water is left stagnant and favours the growth of hyacinth and other weeds. This process has culminated into the process of eutrophication. The dissolved oxygen content of S1 in particular was found to be very low.

Total hardness

The hardness of water samples indicates the foaming ability of water. The flowing and the stagnant water samples were collected from sites where they are used extensively for domestic purposes like washing of clothes, utensils, bathing etc. The water samples collected from stagnant water samples showed that the water in the AC canal (stagnant) was ranging from moderately hard to medium hard. On the other hand the flowing water has values showing it to be soft and on the lower side of moderate hardness. Samples S1 and S4 had high value of hardness which makes it unusable for any domestic activities.

Nitrate

The nitrate content of flowing water is observed to be lesser than the stagnant water and the self-purification process of water replenishes the water quality in the flowing water. Water resources are used extensively for agriculture purposes in the study area and thus the flushing out of water after irrigation will have significant amount of nitrates. Thus the higher values of nitrate in AC is can be explained by the poor flow of water. Nitrate content exceeding 10 mg/L is not advisable for use, especially for children as it may lead to blue baby syndrome.

Phosphate

The phosphate level is similar to the nitrate levels. The increase in the phosphate levels in stagnant water can be explained by the runoff from agricultural fields and domestic wastes dumped into the canal.

Biological contamination

To determine the extent of biological contamination E.coli test was conducted on samples F4, S1, S4, and S6.from visual observation the E.coli could not be counted as the bacteria concentration used for culture was added in excess. However, it was found that there was algae formation in samples S4 and S6. The intensity of orange colour indicating the presence of E.coli was relatively low in sample F4. The environmental problem such as bacteriological pollution, anaerobic conditions and eutrophication is impacting the health conditions of people, water-borne disease being more prevalent

Figure II. Water samples collected from sampling sites.

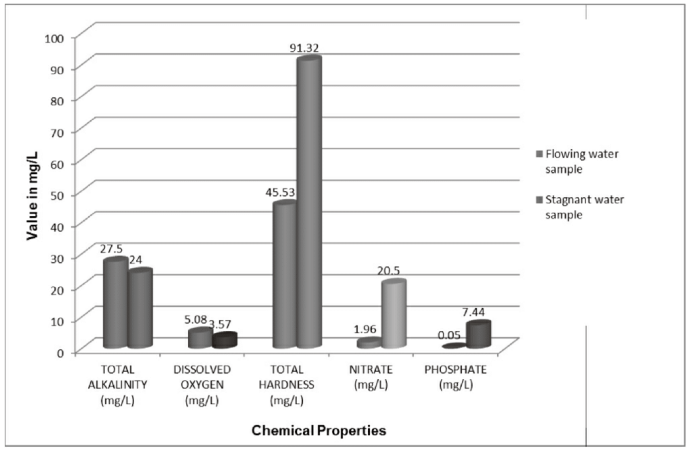
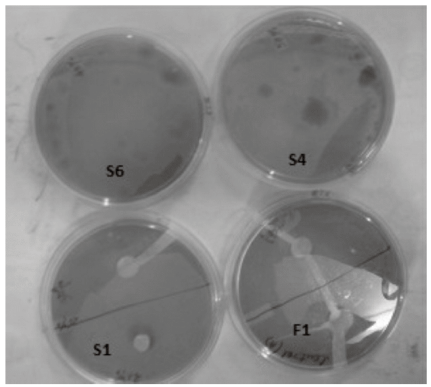


Figure IV. Result of E.coli test



Significance of Water Quality Analysis

Water samples are collected from flowing and stagnant water. Stagnant water is collected from AC canal and this area is specifically selected, because 70% of the total waterborne diseases in Alleppey region are concentrated to the region surrounding the AC canal (www.thehindubusinessline.in./bline). The canal receives its water from a tributary of river pampa and at its inlet and outlet water quality is relatively pure. The water quality at inlet and outlet is given by samples F1 and F4 respectively. Water flow has a good velocity at these points to carry out their self-purification process. The problem thus is the insufficient amount of small canal outlets in this entire path. It is further observed that the blockade caused by landfilling has affected the flow from inlet to outlet.

Kuttanad is famous for its lush green paddy fields and scenic beauty and is a potential site of tourism. The results of this study indicate that there is a degradation of water chemical properties in the stagnant water which is a topic of concern. If the same condition of stagnation persists in future then the projection of the existing results indicates a serious problem in water quality leading to lots of problems associated directly or indirectly with bad water quality.

Ground Water Quality and Level

The water quality parameters for groundwater is analysed from the data acquired from central groundwater board. Each parameter is compared with the Bureau of Indian Standards limits for drinking water.

Groundwater or subsurface water is the major source of water used for drinking and cooking purposes (Khan & Srivastava 2012). The data collected clearly depicts the extent of groundwater pollution. The rise of pH, carbonate and fluoride content is alarming and remedial measures should be taken for replenishing its quality.

The Places selected for the study of water level is a part of the study area in focus. The groundwater level has shown an all-time low value of 0.35 in Nedumudi. Ramankary had its ground water level depleted to 0.29m in the year 2010, however it has improved to 0.68 in 2011.The depletion of water table is illustrated in the graphs below and from the declining trend we must conclude that the potable water resources are getting depleted in the study region.

Table III. Groundwater Quality of Study area in focus (source: cgwb.gov.in)

PROPERTIES	YEAR 2007	YEAR 2008	YEAR 2011	BIS LIMITS
Ph	7.65	8.47	8.94	6.5-8.5
Mg	6.24	5.8	5	30
Nitrate	22	3.3	0.4	45
Phosphate	2.4	5.6	4.9	10
Sulphate	134	4.8	15	200
Carbonate	0	4.8	7.2	75
Bicarbonate	659	115	37	30
Chloride	45	40	43	250
Fluoride	0.11	0.17	0.18	1

Table IV. Average water level in m (source: cgwb.gov.in)

PLACE	YEAR 2007	YEAR 2008	YEAR 2009	YEAR 2010	YEAR 2011
RAMANKARY	0.72	0.45	0.44	0.29	0.68
NEDUMUDI	1.33	0.38	0.4	0.74	0.35

Figure V. Trend of water level in Ramankary

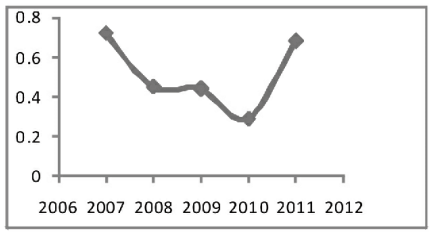
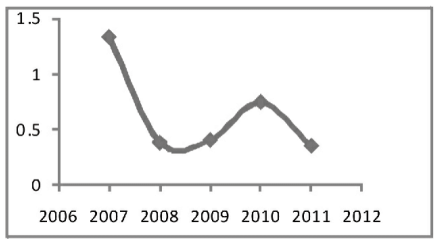


Figure VI.Trend of water level in Nedumudi



Depletion of Wetlands and Water resources

There is a rapid decrease in the water spread area of Kuttanad region in Kerala. A case study of water spread area of Vembanad kayal and its backwater showed a decline of 4.93% during 1983-1992. Similarly the depth of water bodies is also decreasing (MSSRF Report, 2007). Survey at certain points in Vembanad kayal over 50 years showed that water bodies are getting filled and becoming shallower. Furthermore the water carrying capacity of Vembanad kayal has reduced to 78%.Wetlands are very important from environmental aspects and the declaration of three sites as Ramsar sites speaks of the agrarian distress of Kuttanad region. Vembanad kayal is one of the Ramsar sites and its reduction in depth and water spread area endangers the biological diversity in Kuttanad.

Paddy fields can be termed as a manmade wetland and its depletion directly affects the productivity of rice, the staple food of Kerala. The variation in the land use pattern combined with the distress of water quality can be coined as one of the reasons for the decline in agricultural sector. It should be understood that agriculture and all forms of life are affected by the degrading water quality in one way or another.

Suggestions for Improving the Water Quality in the Study Region

Inspection and site survey of the study area in focus has resulted in the finding of number of canals and tributaries that links AC canal to the tributary of river Pampa.These linking canals are indicated in yellow colour line in the Figure 9. According to the local people in the area, these narrow canals of width 4 to 5 m were once used for inland navigation. The decline in the inland water transport has led to the negligence of water resources and has led to its depletion. The google earth image shows the number of small canals in yellow colour which need to be revived immediately, so that it can act as an outlet to improve the quality of water. The revival of canals can provide a short term relief to the existing problems due to degrading water quality. To improve the quality further, blockade of water flow caused by the landfill (red colour line in Figure 9) and bridges (yellow colour place marks in Figure 9) needs to be eliminated.

CONCLUSION

The present study on the water quality of the study area in Allepey district and part of Kuttanad region has certain limitations due the non-availability of information on the epidemic outbreaks. Unscientific and unsustainable constructions of roads and bridges arresting the water flow cause the formation of large pools of stagnant and contaminate water which becomes breeding ground for bacteria and mosquitoes. It is also to be noted that the quality of water standards when entering the AC canal is within the limits and along the course of the AC canal its quality depletes. The water used for

Figure VII. Decline in the water spread area of Vembanad kayal (Source: MSSRF Report, 2007)

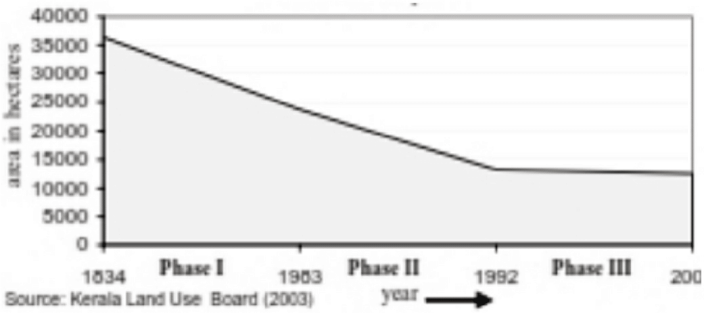


Figure VII. Decline in the water spread area of Vembanad kayal (Source: MSSRF Report, 2007)

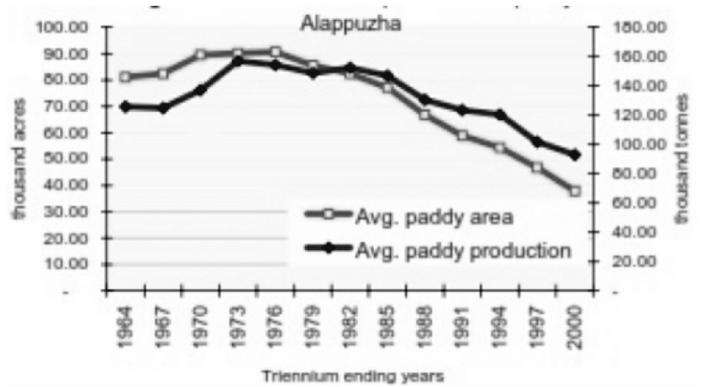


Figure IX. Study area in focus with suggestions to improve the water quality (source: Google earth)

agriculture is the same water which was flushed out in the previous season due to the absence of flow. This process has affected the agriculture sector dearly and immediate actions need to be taken.

Water transport was once the integral part of people in Kuttanad region including Allepey district. The advent of roads and motor vehicles has changed their lifestyles drastically. State water transport department has cancelled their services over the years due to low clearance provided by the bridges and thick vegetation in water which hamper the movement of vessels. The lack of advancement in the water transport in the Kuttanad region has further added to the cause of negligence of water resources. In today's scenario of rising prices, attending to smart use of inland water for navigation will be a step towards a cheaper sustainable alterative of transportation mode and will be much appreciated by the people. Apart from conveyance, once functional the water courses will have many advantages in terms of economic and environmental perspective.

In conclusion, water resources are directly linked to the people's lives in Kuttanad. The revival of many canals in different regions of Kuttanad region will affect the agricultural sector positively and will result in the social upliftment of people in Kuttanad.

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