Minor Water Bodies in Kottayam Municipality Area: A bio-ecological study

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Susy Abraham, Madanakumar C. K*

1. Introduction

Environment is not just a sector of our society or a separate compartment of our existence but an integral part of every day life. Hence in an urban environment, for orderly growth, a long-term plan, not only for industrial and agricultural development, but also for the entire infrastructure or entire environment, utilisation of water resources, transport, power and town planning for the cities, is of paramount importance.

While planning a city, the planners such as a Town Planning Board, invariably keep aside certain areas for putting up parks. Parks are usually referred to as lungs of the city. They are areas where people who live in crowded flats and work in equally crowded offices, can breathe in deep gulps of air and relax.

Similarly, minor water bodies are the kidneys of an area or a city. They are as important as the parks, for a number of reasons such as the following:

Source of water

Water is an essential component of life and is required for most of the vital activities of living beings like drinking, bathing, washing, irrigation, and industrial operations. The water collected in major water bodies is used for some of these activities. Increase in population, ill-conceived industrialisation and urbanisation have made underground water increasingly scarce as well as difficult and expensive to obtain.

Ground-water recharge sources

Water-scarcity is a major problem in nearly all the cities of the world. Underground is the most inexpensive source of water. Rainwater, which accumulates in small water bodies, percolates through the soil and reaches the ground water system or the nearby wells.

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Water-quality improvement

In addition to rainwater, water from drains and sewage pipes, as well as wastewater from industrial houses and households also finds their way into water bodies. In minor water bodies wastewater may cause high concentrations of BOD, COD, nitrates, organic chemicals, and bacteria. Municipal wastes and industrial effluents are known to bring bacteria, viruses, and inorganic and organic chemicals into the water bodies. The problem of pollution from solid waste is the greatest in areas of high rainfall and shallow water table. The leakage from solid wastes increases the concentration of hardness, alkalinity and total dissolved solids of underground water (Todd, et. al, 1976). The water that collects in the minor water-bodies remains in them for sometime till they overflow into nearby streams or percolate into the ground-water system. While remaining in the water bodies the water is acted upon by sunlight, as well as detoxifying and decomposing micro-organisms. The plants that grow in the water bodies take in the polluted water and evaporate pure-water into the air. The water that percolates into the groundwater system also gets filtered and purified to some extent. Thus a process of natural treatment of run-off water takes place with absolutely no economic input.

Recently Sharma (1995) surveyed the ground-water quality of 22 problem areas of different states of India and found that most of the underground water samples were contaminated due to leaching of chemicals or seepage of industrial solid wastes.

Preventing floods

Flooding has now become an annual feature of every city and town, which lies in a rainy region. Kottayam town is no exception. As more and more open areas in the town are getting filled up and buildings constructed on them, rainwater has no alternative but to flood into the nearest low-lying areas, thus forcing large number of families occupying the houses in these low areas to leave them. This problem could be reduced to a certain extent by letting the water flow into minor water bodies. These bodies could be deepened, if needed.

Dispersion of erosive forces

Land degradation by soil erosion is another major problem. Erosion makes soil less able to retain water, depletes it of nutrients and reduces the depth available for the roots to take hold. If the run off water is allowed to flow into minor water bodies, run off distance could be reduced and the effect of erosion decreased.

Sources of indigenous biotic material

Minor water bodies are characterised by relatively quiet waters and abundant vegetation. Large numbers of micro- and macro-organisms dwell in these minor water bodies. The richness of the fauna is dependent mainly on the presence of respiratory gases, the amount of sunlight penetration and turbidity. Temperature fluctuation is also significant. A number of the flora and the fauna are endemic to the area concerned. For example, *Caridina*

natarajani is a fresh-water shrimp, so far reported only from the minor water bodies of Kerala.

Food chain support

The numerous flora and fauna inhabiting the minor water bodies form an important constituent of food chains, bio-geo-chemical cycles, and other ecological interactions.

Control of mosquitoes

Mosquitoes act as vectors for a number of tropical infections and hence are a health hazard. Mosquitoes, especially of the culicine group, are predominant in urban areas, due to insanitary conditions. Rapid urbanisation and industrialisation are responsible for increase in the population of mosquitoes. Stagnant drains, septic tanks, ponds, wells, miscellaneous containers, flowerpots, tree holes, etc. form their favourable breeding sites. Mosquito control is a major problem faced by municipalities. Controlling them would be easier, if there are known, plotted-out water-bodies in a town or city. The use of larvivorous fishes and other eco-friendly methods could be employed, to control them, in these identified habitats.

Economic uses

Aquaculture is a possible means to use the minor water bodies for economical benefit. It is an efficient means of recycling agricultural and domestic wastewater and thus protecting the environment. Pond-fish culture comprising mono-sex culture, mono-species culture, composite fish culture, and predatory fish culture could be practised in minor water bodies.

Aesthetic benefits

Planned construction of minor water bodies could make them beautiful spots for rest and relaxation.

Thus it is very clear that study of minor urban water bodies in an urban area is of great importance. No such study has been conducted, so far, in any of the major urban areas in Kerala. The present endeavour is to fill this lacuna.

Objectives

General

(i) To identify and map the water bodies,
(ii) To study their bio-ecological and biogeographical characteristics,
(iii) To estimate their relevance and environmental impact,
(iv) To assess the level of their pollution, degradation, and depletion caused by human intervention,
(v) To study the effect of their changes on ground water level, and
(vi) To suggest methods of their conservation and of finding alternative water resources.

Collection and analysis of data

The study would be carried out in a series of steps outlined below.

Mapping of minor water bodies

Survey of the Kottayam Municipality area and identification and mapping of minor water bodies.

Physico-chemical parameters

Estimation of rain fall and analysis, water depth, water input and output, atmospheric and water temperature, water transparency, dissolved oxygen, pH, free carbon dioxide, phenolpthalene alkalinity, methyl orange alkalinity, total alkalinity, conductivity, chloride, inorganic phosphate, calcium, magnesium, and biological oxygen demand.

Limnology

(i) Assessment of biomass of both phyto-, and zoo-plankton and their seasonal and annual variations.
(ii) Determination of primary productivity in the water spread area and its seasonal and annual variations.

Vegetation

Gathering of information on the aquatic plants present in the study area.

Fauna

(i) Collection of data on the aquatic macro-invertebrates, their biomass and seasonal variations.
(ii) Survey of insects, fish, birds, mammals and any other organisms associated with the water bodies.

Pollution

Survey of the level of pollutants: oil pollutants, organic pollutants, etc.

Groundwater

Measurement of changes in the water level in the wells surrounding the water bodies.

Study of methods to initiate action at the local level

Formulation of methods to initiate action. For this purpose, co-operation of students, the public, NGOs and media would be sought. Seminars would be held to disseminate ideas and receive feedback.

It is expected that the analysis of the data collected would highlight the bio-ecological importance of minor urban water bodies, their relation with ground water level and their pollution and would create social and mass media interest in these water bodies. It would also bring about the interaction and intervention between non-governmental and governmental organisations essential for preventing the misuse and decay of the minor water bodies.

2. Materials and Methods

Method

Based on the objectives of the study, the method for the collection of data was selected.

Survey with field study

At the outset, appropriate maps and information on the relevant features of the study area were collected from the Municipality authorities, and CWRDM, Kottayam. A direct field survey was then conducted. All relevant information about each minor water body was collected through the survey. During the field survey photographs and slides to highlight the specific features of each minor water body were prepared.

Analysis of physico-chemical parameters

For the specific study of the bio-ecological nature of the minor water bodies, three of the water bodies were selected: the first from the lowland area with fairly clear water (Pond No. 21), the second from midland area with slightly polluted water (Pond No. 35), and the third from the wet land area with highly polluted water (Pond No. 32). Water samples were collected on a monthly basis from September 1997 to August 1998 except April and May 1998, since the level of water was found extremely low during these months. The analysis was conducted in the laboratory of the Department of Zoology of the CMS College, Kottayam. Analysis of physico-chemical parameters was conducted using standard analytical methods.

Description of the study area

Kottayam municipality area

The location of the study area is shown in Figures 2.1 and 2.2. Further details are furnished below:

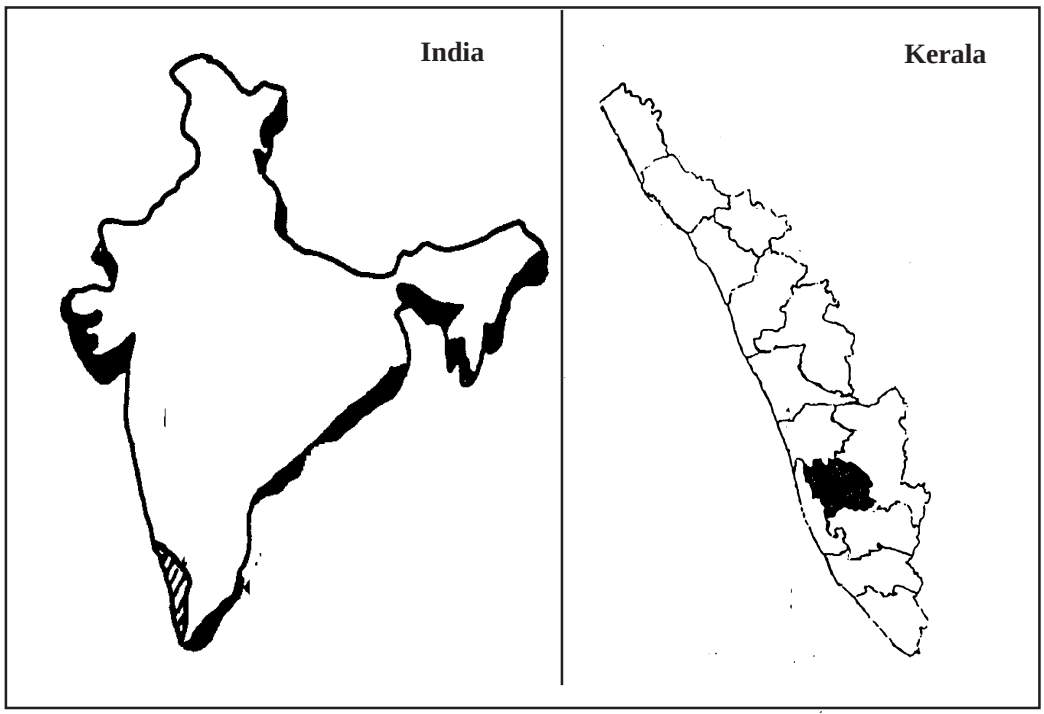
Location

Longitude	:	Between 9^0.34‘ and 9^0.36‘ N.
Latitude	:	Between 76^0.34‘ and 76^0‘.36‘ E.
Area	:	15.55sq. km.

Boundaries

East	:	Vijayapuram *panchayat*
West	:	Thiruvarp *panchayat*
North	:	Aymanam, Kumaranallooor *panchayat*
South	:	Nattakom *panchayat*

Figure 2.1 Location of the study area



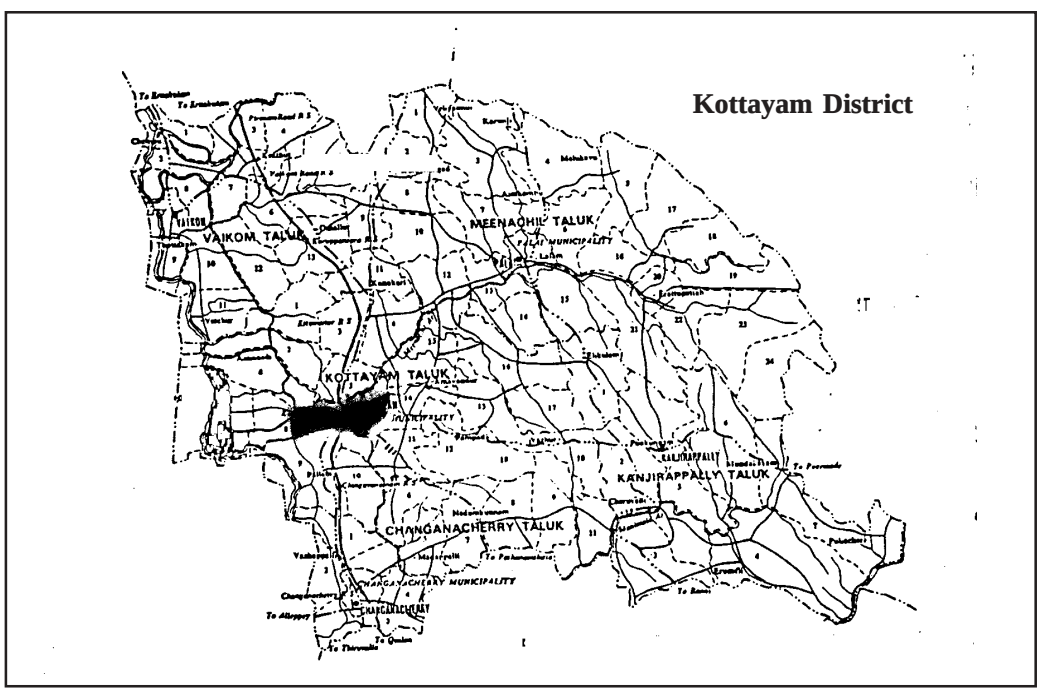


Figure 2.2 Location of Kottayam municipality area

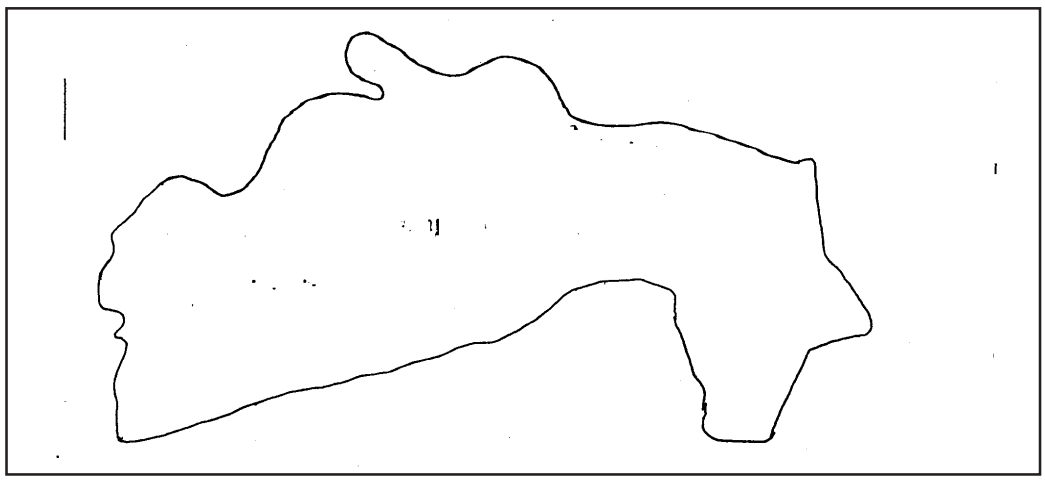


Figure 2.3 Location of minor water bodies in the study area (Kottayam Municipality Area)

48 –Water bodies

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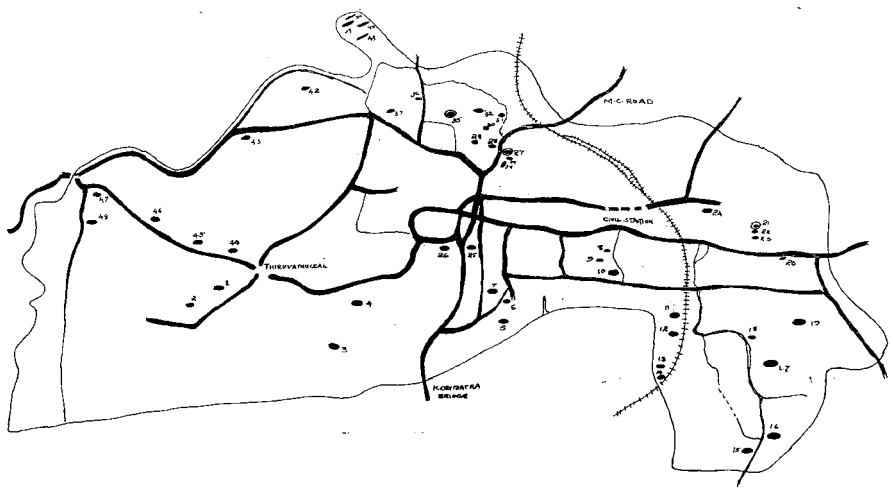
Pond Selected for Chemical Analysis

1.Pond No. 21

2.Pond No. 27

3.Pond No. 35



The Kottayam municipality area, which covers three villages (Kottayam, Muttambalam, and Veloor) is divided into the following 32 wards.

Ward No.	Name	Area (sq. km)
1	Eranjal	0.2475
2	Manganam	0.675
3	Devalokam	0.75
4	Kanjikuzhy	0.355
5	Muttambalam	0.7875
6	Holy family	0.435
7	Convent	0.3125
8	Railway station	0.3625
9	Hospital	0.235
10	Civil station	0.80
11	M.D. Seminary	0.293
12	Cathedral	0.26
13	Kodimatha	0.5875
14	Vayaskara	0.4225
15	Union Club	0.29
16	Nagambadom	0.3654
17	Tirunakara	0.3425
18	Kurisupalli	0.2255
19	Pazhaya seminary	0.82
20	Thaliyilkotta	0.3052
21	Thirumala	0.37
22	Valiakunnupuram	0.4524
23	Puthenangadi	0.3725
24	Boat Jetty	0.3656
25	Sastankovil	0.4875
26	Ambalakadav	0.4875
27	Thazhathagadi	0.46
28	Karapuzha	0.96
29	Pulinakkal	0.72
30	Veloor	0.71
31	Parappadom	0.44
32	Kanjiram	0.9025
	Total	**15.55 sq.km**

Based on the topography, the Kottayam Municipality area falls under three regions:

(i) Lowland comprising Thazhathangadi, Veloor, Thiruvathuckal, Karapuzha, Eranjal,Nagampadom, Chandakadav, Chungam, Old seminary, Mullenkuzhy, and Kanjikuzhy areas;

(ii) Midland **c**onsisting of CMS College, Annan kunnu, and Civil Station areas; and

(iii) Highland covering Devalokam, Muttambalam, and Basalius College areas**.**

Observation

The details of the 48 water bodies covered under the field survey are furnished in the following description and Tables 1 to 4.

Details of the minor water bodies based on direct survey

(Age: approximates; Biota: only prominent ones mentioned)

Pond No. 1

Location	:	Thiruvathuckal, (Ward No. 29; Pulinakal), Lowland
Ownership	:	Private
Dimensions	:	Area: 300m^2, Volume = 1500m^3
Age	:	27 years
Description	:	Rectangular shape; Outlet is present; Natural pond, muddy water, Annually flooded; Used for fish culture.
Flora	:	Algal blooms
Fauna	:	Frogs, Fishes

Pond No. 2

Location	:	Thiruvathuckal, (Ward No. 29, Pulinakal, 750m from CWRDM). Lowland
Ownership	:	Ittycherian, Krupa - Pulinakal
Dimensions	:	Area : 50m^2, Volume : 250m^3
Age	:	20 years old
Description	:	Rectangular shape; No inlet or outlet; During monsoons, area is flooded. Muddy soil; Used for fish culture.
Flora	:	Algal blooms, Grasses
Fauna	:	Aquatic insects, Frogs, Fishes

Pond No. 3

Location	:	Karapuzha, (Ward No. 28), Lowland
Local name	:	Parakkulam
Ownership	:	C.V. Jacob, Nanthyaltu
Age	:	20 years

Dimensions	:	Area : 120m^2, Volume : 240m^3
Description	:	Oval shape; Pond formed due to quarry work; No inlet or outlet; Used for fish culture; clear water
Flora	:	Algal blooms;
Fauna	:	Frogs, Fishes

Pond No. 4

Location	:	Karapuzha, (Ward No. 28), Lowland
Ownership	:	Public
Age	:	25 years
Dimensions	:	Area : 20m^2, Volume : 80m^3
Description	:	Rectangular shape; Inlet and outlet present; Outflow takes place, near to the Karapuzha bridge, into the Karapuzha *Thodu*.
Flora	:	Salvinea, Eichornia,
Fauna	:	Fishes, Snakes, Frogs.

Pond No. 5

Location	:	Erakadav; Near to KSRTC Bus stand, Low level area, Lowland (Ward No:13)
Ownership	:	Private.
Dimensions	:	Area : 35m^2, Volume = 140m^3
Age	:	16 years
Description	:	Rectangular shape; Erakadav is a highly polluted, two acres of flood wetland; Waste from a timber factory pollutes the pond; Inlet and outlet present. The whole area is polluted with sewage water from the city, factory etc; Outlet is to Kodoor River.
Flora	:	Grasses, Pandanus, Colocassia, etc.
Fauna	:	Mosquito larvae, Snakes, Frogs, etc.

Pond No. 6

Location	:	500m from KSRTC Bus stand (Ward No. 13)
Ownership	:	Public
Dimensions	:	Area : 9m^2, Volume : 45m^3
Age	:	30 years
Description	:	Square shaped; Natural; No inlet or outlet; Sewage disposal takes place. Perennial; Not used for health-related purposes; It is situated near to an old tile factory.
Flora	:	Grasses, Algae, etc.
Fauna	:	Worms, Insect larvae.

Pond No. 7

Location	:	Approximately 300m from Pond No: 6 (Ward No.13)

Ownership	:	Public
Dimensions	:	Area: 12m^2, Volume = 60m^3
Age	:	30 years
Description	:	Rectangular shape; Natural; No inlet or outlet; Sewage, Vegetable disposal area; Not used for health-related purposes. This is also near to the tile factory.
Flora	:	Algal blooms, Grasses
Fauna	:	Frogs, Snakes

Pond No. 8, 9

Location	:	Approximately 350m from Collectorate area, (Ward No. 10)
Ownership	:	Private.
Dimensions	:	Area: 6m^2, Volume : 30m^3
Age	:	15 years
Description	:	Rectangular shape; No inlet or outlet; Isolated; Situated in a rubber estate; Perennial; Clear water.
Flora	:	Algal blooms
Fauna	:	Aquatic insects, Frogs

Pond No. 10

Location	:	Approximately 150m from pond 9 (Civil Station) (Ward No. 10)
Ownership	:	Public
Dimensions	:	Area: 70m^2, Volume : 420m^3
Age	:	20 years
Description	:	Rectangular in shape; 3 inlets are present; These inlets let in polluted water from the city; The pond acts as a dumping station for vegetables, sewage, etc.
Flora	:	Grasses
Fauna	:	Aquatic insects, Worms

Pond No. 11

Location	:	Near Railwayline, Muttambalam (Ward No. 5)
Ownership	:	John Chacko, Mattathil
Dimensions	:	Area: 18m^2, Volume : 126m^3
Age	:	That of railway line
Description	:	Rectangular shape; Pond formed due to quarry work for railway line: Local name – Parakkulam; No inlet; Not used for health-related purposes.
Flora	:	Algal blooms, Pandanus, grass
Fauna	:	Fishes, Turtles, Frogs

Pond No. 12

Location	:	200m from Pond No. 11 (Ward No. 5)

Ownership	:	Private.
Dimensions	:	Area: 18m^2, Volume : 45m^3
Age	:	15 years
Description	:	Oval shape; It is a tank used for dumping the waste of a rubber (latex) factory. Now it is not used and is highly polluted; perennial.
Flora	:	Collocassia, Pandanus
Fauna	:	Frog, Snakes

Pond No. 13, 14

Location	:	Near to Kodur River (Ward No.13)
Ownership	:	Private
Dimensions	:	Area: 150m^2, Volume : 600m^3
Age	:	35 years
Description	:	It is a rectangular mini wetland; Covered with Eichornia, Salvenia, etc. Some parts are very deep; Perennial; connected to Kodur River.
Flora	:	Eichornia, Salvinea, Water Lilly
Fauna	:	Aquatic insects, Frogs, Fishes, Turtles

Pond No:15,16

Location	:	Near to the east boundary of Kottayam Municipal area. i.e., near to the Padinjareakara Rubber factory (Ward No. 2)
Ownership	:	Private.
Diamensions	:	Area: 600m^2, Volume = 1800m^3
Age	:	25 years
Description	:	Rectangular; The two are more or less of equal size; Flooded with water and waste materials from the factory and sewage, highly polluted; This area is connected to the Kodur river by outlet.
Flora	:	*Eichornia, Salvinea*
Fauna	:	Fishes, Turtles

Pond No. 17

Location	:	Manganam (Ward No.2)
Local Name	:	Parakkulam
Ownership	:	Private
Dimensions	:	Area: 350m^2, Volume : 700m^3
Age	:	45 years
Description	:	Oval shaped; Water body formed by quarry works; No inlet; Outlet present to Kodoor River; Used for fish culture (Perennial)
Flora	:	Water lily, Algal blooms, Salvinia

Fauna	:	Frog, Fishes

Pond No. 18

Location	:	Manganam (Near to the road) (Ward No.2)
Ownership	:	Public
Dimensions	:	Area: 84m^2, Volume = 336m^3
Age	:	25 years
Description	:	Small wetland; Perennial; Used for sewage disposal; Highly polluted; Inlet and outlet present.
Flora	:	Grasses, Water lily, Salvinia
Fauna	:	Aquatic Insects, Frog, Snakes, Small Fishes

Pond No. 19

Location	:	Manganam (Ward No.2)
Ownership	:	Public
Dimensions	:	Area: 200m^2, Volume : 600m^3
Age	:	25 years
Description	:	Small wetland; Perennial; Not used; Sewage flows in; Inlet and outlet are present. The inlets are from the road side.
Flora	:	Grasses, Algal blooms
Fauna	:	Aquatic Insects

Pond No. 20

Location	:	Kanjikuzhy (Ward No.4)
Ownership	:	Private
Dimensions	:	Area: 40m^2, Volume : 240m^3
Age	:	30 years
Description	:	Rectangular shape; No inlet or outlet; Perennial water body; Polluted water; Now used for sewage dumping.
Flora	:	Colocassia, Pandanu, Grass
Fauna	:	Frog, Fishes, Snakes, Water Birds

Pond No. 21, 22, 23

Location	:	Kanjikuzhy (Ward No.4)
Ownership	:	M. V. Joseph, Valachirayil
Dimensions	:	Area: 1.5m^2, Volume : 4.5m^3
Age	:	35 years
Description	:	More or less oval in shape; Ponds 22 and 23 are 15m metres awayfrom pond 21. These three ponds have no inlets, but outlets are present; The water in the ponds is used for household purposes.
Flora	:	Water Lilly

Fauna : Small Fishes

Pond No. 21 (Selected for sample analysis)

Used for home purposes; Filter mechanism present; Clear water; Flowing water all year round; People conserve this pond. (Water lily and little algal blooms are seen). Since Kanjikuzhy is lowland, the pond has plenty of water at all seasons.

Fauna : Small Fishes

Pond No. 24

Location : Mullankuzhy : Next to Gandhi Nagar Colony (Ward No. 21)
Ownership : Public
Dimensions : Area: 120m^2, Volume : 600m^3
Description : More or less rectangular in shape; No inlet and outlet; Sewage disposal from Gandhi Nagar Colony flows into the pond; The inlets are from the road side.
Flora : Colocassia, Grasses

Pond No. 25

Location : Thirunakkara Temple (Ward No.17)
Ownership : Devaswam Board
Diamensions : Area: 200m^2, Volume : 600m^3
Description : Used for bathing; no inlet or outlet.
Flora : Hydrilla, Algal blooms
Fauna : Frog, Fishes, Snakes

Pond No. 26

Location : Thirunakkara (Vayaskara Region) near Rest house (Ward No.14)
Ownership : Vayaskara Vaidyasala
Dimensions : Area: 16m^2, Volume : 80m^3
Description : Square shaped pond; Clear water; This is a special pond with ayurvedic herbs (Brahmi - Ramacham); Pleasant smell; Many years ago, the water from the pond was used for preparation of ayurvedic medicines; No inlet or outlet; Now in disuse.
Flora : Algal blooms
Fauna : Aquatic Insects

Pond No. 27, 28, 29, 30, 31, 32, 33, 34 (Pond No. 27 taken for sample analysis)

Location : Nagampadam (Ward No. 16)
Ownership : Public
Dimensions : Area: 24m^2, Volume : 96m^3

Description	:	These minor water bodies are situated near to Nagampadam Bus stand, M.C.road, and Baker Jn; Most of them are perennial; Now these ponds are used as sewage dumping stations; The minor bodies are inter-connected; Highly polluted area; Polluted material, water, etc., from automobiles, shops, and city canals flow in; The inter connections have been broken by human activity in some areas.
Flora	:	Algal blooms
Fauna	:	Aquatic Insects, Frogs

Pond No. 35 (Taken for sample analysis)

Location	:	Near to CMS College (Ward No.19)
Ownership	:	Private
Dimensions	:	Area: $100m^2$ x $100m^2$ = 10000 m^3
Age	:	40 years
Description	:	Very old, wetland area; Covers about 1.5 acre; Perennial; Inlet and outlet present; This wetland is connected with Meenachil River. In the monsoon season, this area gets highly flooded; This wetland acts as breeding ground for fishes, frogs, etc.
Flora	:	Eichornia, Salvinia, Water lilly, Utricularia
Fauna	:	Fishes, frogs, snakes, herons, kingfishers, rats

Pond No:36,37

Location	:	Near to Chungam (Nagampadam ward) (Ward No. 16)
Ownership	:	Public
Dimensions	:	Area: $70m^2$, Volume : $420m^3$
Age	:	20 years
Description	:	Rectangular, moderate-sized wetland; Situated near the Chungam-Kottayam Road; Formed due to human intervention; Acts as sew age dumping place for various houses; Water from road canals also flows into it; No outlet. Highly polluted area; During the monsoon season this area is flooded; This pond then overflows.
Flora	:	Grasses, Algal blooms
Fauna	:	Frogs, insect larvae, worms, etc.

Pond No. 38, 39, 40, 41

Location	:	Old Seminary (Ward No. 19)
Diamensions	:	Area: $150m^2$, Volume : $600m^3$
Age	:	10 years
Description	:	These water bodies are channels, situated in the Rubber Estate of the *Pazhaya* Seminary Monastery;These channels are more or less of the same length; Promote growth of rubber trees; No inlet or outlet; So there is no water circulation; The dry leaves of rubber

falling into these channels undergo decomposition; Mosquito population is high; Water quality is the same as that of the Meenachil River.

Pond No. 42

Location	:	Thazhathangadi (Ward No.27)
Dimensions	:	Area: 48m^2 Volume : 600m^3
Age	:	30 years
Description	:	Rectangular water body; Situated near Juma Masjid, Thazhathangady; Perennial; Near road side; No inlet or outlet; In monsoon season these areas are flooded; Covered with Salvena; Lots of fishes live in them; Not used for health-related purposes. It is used for sewage disposal; Not protected.
Flora	:	Salvinia, Eichornia
Fauna	:	Fishes, frogs, Insect larvae

Pond No. 43

Location	:	Thazhathangadi (Near Government Muslim LP School) (Ward27)
Dimensions	:	Area: 15m^2, Volume : 60m^3
Age	:	20 years
Description	:	Rectangular; Inlet and outlet exist; Used for bathing; Outlet is narrow; Opens into a canal that flows into Meenachil River.
Flora	:	Algal bloom, Eichornia, Salvinia, Oistia, Hydrilla
Fauna	:	Fishes, Snails, Frogs, Snakes, Turtles

Pond No. 44

Location	:	Thiruvathukal (Ward No.29)
Ownership	:	Private
Age	:	25 years
Description	:	Rectangular; Well-protected; Used for bathing; clear water, no inlet; outlet present.
Flora	:	Lotus, Waterlily, Pistia, Submerged plants
Fauna	:	Fishes, Frogs, Snakes, Turtles

Pond No. 45

Location	:	Veloor (Ward No.30)
Ownership	:	Public
Dimensions	:	Area: 12m^2, Volume : 48m^3
Age	:	18 years
Description	:	Small rectangular water body; Formed by human intervention; Perennial; Inlet from road canals; No outlet. In monsoon season, gets flooded.

Flora	:	Lotus, Waterlily, Pistia, Submerged Plants
Fauna	:	Fishes, Frogs, Snakes, Turtles

Pond No. 46

Location	:	Veloor; Approx 1 km than Pond No:45 (Ward No. 30)
Ownership	:	Private
Dimensions	:	Area: 84m^2, Volume : 42m^3
Age	:	25 years
Description	:	Size moderate; Situated near road side; Inlet and outlet present; (Connected with water canals); Used for bathing animals (cow, buffalo, etc).
Flora	:	Waterlily, Pistia, Submerged Plants
Fauna	:	Fishes, Frogs, Turtles

Pond No:47

Location	:	Near to Illickal Bridge (500m) Veloor (Ward No:30)
Ownership	:	Private
Dimensions	:	Area : 144m^2, Volume : 100m^3
Age	:	30 years
Description	:	Moderate-sized; Approximately square-shaped; Well-protected; Clear water; Used for bathing purpose; Inlet absent; Outlet present.
Flora	:	Lotus, Waterlily, Pistia, and Submerged Plants
Fauna	:	Fishes, Frogs, Turtles, Aquatic Insects

Pond No. 48

Location	:	Veloor (Ward No:30)
Ownership	:	Public
Dimensions	:	Area: 12m^2
Age	:	20 years
Description	:	Situated near the road side (Illickal-Kanjiram Road); Inlet and outlet present; Not in use; Sewage disposal also seen.
Flora	:	Colocassia, algalblooms, pandana, grasses
Fauna	:	Snakes, frogs

Table 2.1 Details of water bodies

Pond No:	Inlet	Outlet	Ownership	Age (Years)
1	Absent	Present	Private	27
2	Absent	Absent	Private	20
3	Absent	Absent	Private	20
4	Present	Present	Public	25
5	Present	Present	Private	16
6	Absent	Absent	Public	30
7	Absent	Absent	Public	30
8 -9	Absent	Absent	Private	15
10	Present	Absent	Public	20
11	Absent	Absent	Private	30
12	Present	Absent	Private	18
13 - 14	Absent	Present	Private	35
15 -16	Present	Present	Private	25
17	Absent	Present	Private	45
18	Present	Present	Public	25
19	Present	Present	Public	25
20	Absent	Absent	Private	30
21 - 23	Absent	Present	Private	35
24	Absent	Absent	Public	Not known
25	Absent	Absent	Private	26
26	Absent	Absent	Private	Not known
27 - 34	Present	Absent	Public	Not known
35	Present	Present	Private	40
36 - 37	Present	Absent	Public	20
38-41	Absent	Absent	Private	10
42	Absent	Absent	Public	30
43	Present	Present	Public	20
44	Absent	Present	Public	25
45	Present	Absent	Public	18
46	Present	Present	Private	25
47	Absent	Present	Private	30
48	Present	Present	Public	20

Table 2. 2 Data showing the various levels of bio-physico chemical parameters of pond no. 21 (1997 Sept. – 1998 Aug.)

	KANJIKKUZHY											
	Month / Parameters	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
PHYSICAL	T^0C	28.9	29	28.7	28.2	28.5	29.3	29.8	-	-	26.9	27	27.1
	pH	6.5	6.1	6.3	6.26	6.5	6.71	6.76	-	-	6.58	6.05	6.63
	NTU	1.8	1.9	1.7	1.8	1.6	2.61	2.82	-	-	1.72	1.75	1.78
CHEMICAL	O_2 Mg/L	7.5	7.2	6.81	7.21	7.6	7.2	7.13	-	-	8.1	8.01	7.92
	CO_2 Mg/L	9.25	9.7	9.91	10.86	10.21	10.76	10.52	-	-	8.18	8.65	9.12
	P Mg/L	8.02	7.25	6.85	8.54	7.37	6.52	8.67	-	-	7.98	8.06	8.13
	HARD Mg/L	50.12	47.51	46.11	48.21	44.2	45	43	-	-	47.2	45	42.8
	CAL Mg/L	16.35	14.48	16.71	17.21	16.13	15.84	16.46	-	-	14.74	13.78	12.82
	Mg + + Mg/L	33.77	33.03	29.98	31	28.07	29.8	26.54	-	-	32.46	32.02	29.58
	CHLD Mg/L	7.54	5.94	6.36	5.81	6.42	5.60	5.81	-	-	6.52	6.40	6.28
	SLATY Mg/L	8.18	8.14	8.72	7.14	7.77	8.12	7.98	-	-	7.38	7.55	7.72
	ALKNTY Mg/L	5.92	6.14	6.31	5.8	6.2	6.5	5	-	-	5.16	5.46	5.76
BIOLOG-ICAL	BOD Mg/L	66.11	67.87	64.6	59.61	68.12	58.08	62.34	-	-	68.24	67.18	66.1

Table 2.3 Data showing the various levels of bio-physico chemical parameters of pond no. 27 (1997 Sept. – 1998 Aug.)

	NAGAMPADAM											
	Month / Parameters	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
PHYSICAL	T^0C	27.8	28.1	28.6	29.7	30.6	31.2	33.00	-	-	26.3	26.6	27.2
	pH	6.5	6.71	6.51	6.72	6.41	6.55	6.82	-	-	6.2	6.35	6.5
	NTU	50.1	53.7	52.81	55.7	54.6	57.12	56.6	-	-	52.8	52.03	51.26
CHEMICAL	O_2 Mg/L	1.21	0395	0.30	0.32	0.26	0.21	0.27	-	-	3.18	3.39	3.6
	CO_2 Mg/L	11.23	13.2	12.82	13.14	13.68	14.1	14.7	-	-	10.8	10.7	10.6
	P Mg/L	372	364	348	322	367	356	351	-	-	358	360	363
	HARD Mg/L	147	161	168	152	164	158	167	-	-	143	144	145
	CAL Mg/L	68	73.3	76.2	68.6	70.12	66.7	72.3	-	-	62	63.65	65.3
	Mg + + Mg/L	79	87.7	91.8	93.4	93.88	91.13	94.7	-	-	6.82	7.01	7.21
	CHLD Mg/L	7.78	9.789	9.37	9.81	10.21	8.68	9.21	-	-	14.39	14.75	15.12
	SLATY Mg/L	16.83	17.69	17.12	16.61	17.32	18.21	17.62	-	-	14.39	14.75	15.12
	ALKNTY Mg/L	1.27	1.25	1.27	1.21	1.28	1.2	1.3	-	-	1.21	1.56	1.91
BIOLOG-ICAL	BOD Mg/L	41.67	40.1	42.11	41.82	40.61	42.7	40.13	-	-	40.82	41.08	41.34

Table.2.4 Data showing the various levels of bio-physico chemical parameters of pond no.35 (1997 Sept. - !998 Aug.)

	CHUNGAM											
	Month / Parameters	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
PHYSICAL	T^0C	29.5	28	28.2	28	28.8	29.1	30.5	-	-	27.6	27.9	28.2
	pH	6.8	6.5	6.2	6.61	6.83	6.73	6.95	-	-	6.8	6.75	6.71
	NTU	2.13	2.9	2.63	2.58	2.77	3.68	3.75	-	-	3.68	3.41	3.14
CHEMICAL	O_2 Mg/L	5.87	5.13	5.24	4.78	4.1	4.82	5.61	-	-	6.17	6.03	5.89
	CO_2 Mg/L	9.82	10.12	10.6	10.47	11.2	11.47	10.81	-	-	9.67	9.82	9.97
	P Mg/L	19.72	15.60	16.82	15.11	14.87	13.48	15.87	-	-	17.12	16.40	15.68
	HARD Mg/L	47	51	55	48	52	61	54	-	-	42	44	46
	CAL Mg/L	12.25	16.66	17.11	16.68	16.81	17.68	17.23	-	-	11.62	11.77	11.92
	Mg + + Mg/L	34.75	34.4	37.39	31.32	35.19	43.84	36.77	-	-	30.38	32.23	34.08
	CHLD Mg/L	5.72	5.53	6.12	6.86	6.71	6.41	5.48	-	-	4.24	4.46	4.68
	SLATY Mg/L	9.182	10.01	10.89	9.54	10.28	10.76	10.92	-	-	7.16	8.03	8.90
	ALKNTY Mg/L	1.29	1.38	1.42	1.2	1.32	1.5	1.2	-	-	1.26	1.25	1.25
BIOLOG-ICAL	BOD Mg/L	63.12	66.11	63.85	60.18	62.13	58.02	55.32	-	-	49.12	51.49	53.86

3. Findings and Discussion

Forty-eight minor water bodies were identified and surveyed in Kottayam Municipality area. Their age varies roughly between 10 to 40 years. They occupy a total area of 5.33 sq. km, which is about one-third the area of Kottayam Municipality. They range in size from 1.5 sq.m to 1000 sq.m. Twenty-nine per cent of them have only inlets, 19 percent have only outlets, 21 per cent have both inlets and outlets and 31 per cent have neither inlets nor outlets.

A study of the physico-chemical parameters of the water bodies revealed that only 6.94 per cent of them were fairly clear enough to be used for any domestic purpose. The rest were polluted in one form or the other (Water which contains inorganic, organic, biological or physical foreign substances is said to be polluted).

Source of pollution

Industrial waste

Water bodies No. 5 – Timber factory
No.7 – Tile factory
No. 12 – Latex factory and
No: 15-16- Rubber factory

Town drainage

Water bodies No. 5, 10, 18, 19, 20, 27, 34, 36, 37, and 48

Sewage from houses and hotels

Water bodies No. 24, 27, 34, 36, 37, 42,

Organic waste

E.g. Water bodies No. 6,7, 10, and 46
The untreated sewage water and the organic waste flowing into the water bodies contain pollutants such as Na, K, Ca, Mn, HCO_3 and So_4, in dissolved form, as well as fatty acids, esters, amino-acids, synthetic detergents and other organic substances, which lead to eutrophication. The wastewater also contains pathogenic viruses, bacteria, parasitic worms, etc.

The water bodies are presently being used for a number of purposes. Fish is being cultured in 15.36 per cent of the water bodies; another 6.94 per cent is being used for domestic purposes. Organic waste from houses, vegetable shops, and restaurants is dumped into 36.33 per cent of water bodies. One of them was used for pharmaceutical purposes; a small proportion – 0.5 per cent – has been beautified and has some aesthetic value. Another 27.63% serves only as wetland and helps mainly in mitigating the effect of floods.

Table 3.1 Uses of minor water bodies

Uses	No. of pond	Area (m^2)	Percentage	Degree
Fish culture	4	820	15.36	55.310
Home Purpose	6	370.5	6.94	24.990
Sewage Disposal	18	1939	36.33	130.804
Aesthetic Purpose	2	3	0.06	0.202
Wetland	6	1475	27.63	99.500
Not used	12	729	13.66	49.170
Total	48	5336.5	100	360

Bio-physico-chemical parameters

Three of the 48 water bodies surveyed were chosen for detailed analysis of the water. They are Pond No. 21 (Kanjikkuzhy), Pond No. 35 (Chungam), and Pond No. 27 (Nagampadom). The first Pond (No.21, Kanjikkuzhy) is representative of a fairly clear water body. A natural filter mechanism is present and the water is used for domestic purposes.

The second (Pond No. 35 Chungam) is slightly polluted and is used for fish culture. Pond No. 27 (Nagampadom) is highly polluted and is used as a sewage-dumping centre; drainage canals flow into it.

Physical parameters

Water temperature

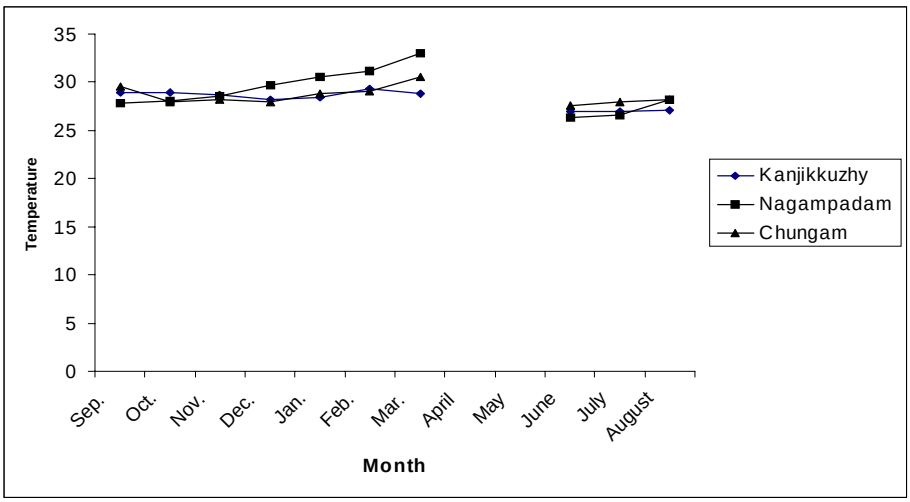
The temperature in the three water bodies ranges between 26°C to 30°C. The temperature is slightly higher in Pond No. 32, where pollution is higher.

Temperature shows an inverse correlation with dissolved oxygen and direct correlation with pollution. Water has a higher oxygen holding capacity at lower temperatures (Jindal and Vasist, 1985; Singh et.al, 1986; Jindal and Kumar, 1990). Water temperature depends on volume. The lentic system under study has low volume of water and exhibits fluctuations in temperature. When temperature is high, solubility of water is low (Welsch, 1952). Temperature also acts indirectly by causing changes in density and viscosity of water (Welsch, 1952).

Aquatic organisms possess a narrow range of temperature tolerance, since there is no great difference between maximum and minimum temperature in aquatic systems (Jaffries and Mills, 1990). In the study areas, the minimum temperature was 26.3 °C and the maximum 33 °C. Generally, the range of tolerance within which the organisms carry on their life activities lies between 10-48 °C. All metabolic processes are influenced by fluctuations in temperature. Increase in temperature increases the enzymatic activity, which results in an increased rate of metabolism. In plants, the rates of photosynthesis, transpiration and respiration are affected by temperature. Temperature fluctuations also affect growth. Temperature imposes

a restriction in the distribution of species. The rate of oxygen consumption and carbon dioxide output doubles with a temperature increase of 10 °C. In warmer waters aquatic organisms have a greater daily food requirement; conversely they have a smaller daily requirement in cold water (Welsch, 1952).

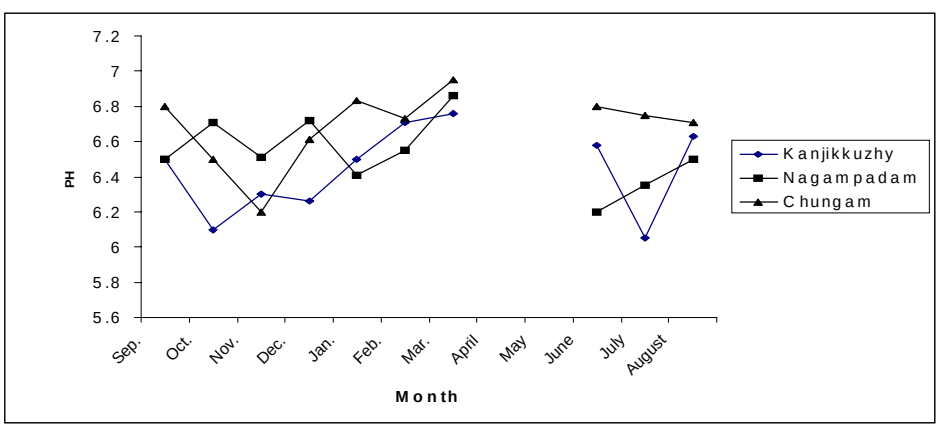
Figure 3.1 Monthly water temperature during September 1997 - August 1998



pH

Measurement of pH is one of the most important and frequently used tests in water-chemistry. The pH values in the three water bodies do not show much variation. They range between 6.10 and 6.95. This is related to the very slight fluctuation in temperature. A decrease in pH would occur if temperature increases, since there would be a greater decrease of carbon dioxide level due to the high rate of decomposition of organic matter, as have been confirmed by the works of Jindal and Kumar (1989).

Figure 3.2 Monthly pH values in three water bodies: September 1997 - August 1998

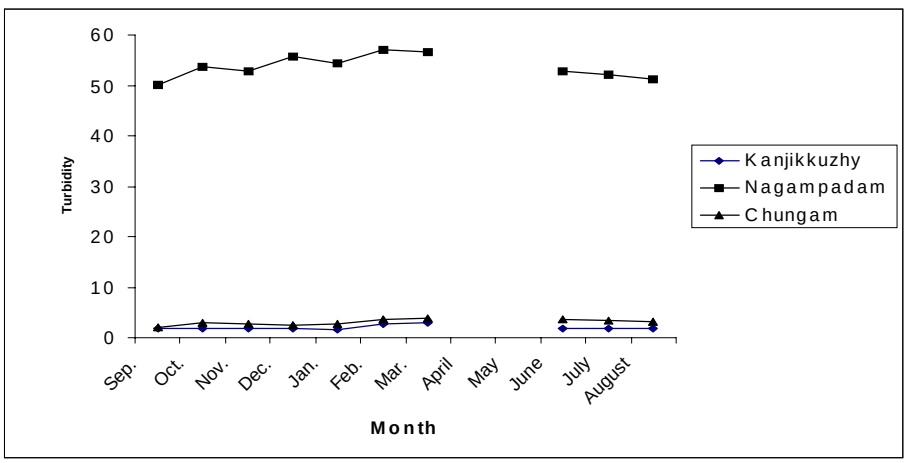


Turbidity (NTU)

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. Turbidity is very high in the polluted water body at Nagampadom and fairly low in the other two. Higher levels of dissolved organic matter and inorganic waste lead to increased turbidity in the polluted water body.

The transparency of water determines the depth to which light can penetrate and at which photosynthesis can take place. Turbidity in water is caused by suspended matter such as clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, plankton, and other microscopic organisms.

Figure 3.3 Monthly turbidity values in three water bodies: September 1997 - August 1998



Chemical parameters

Oxygen

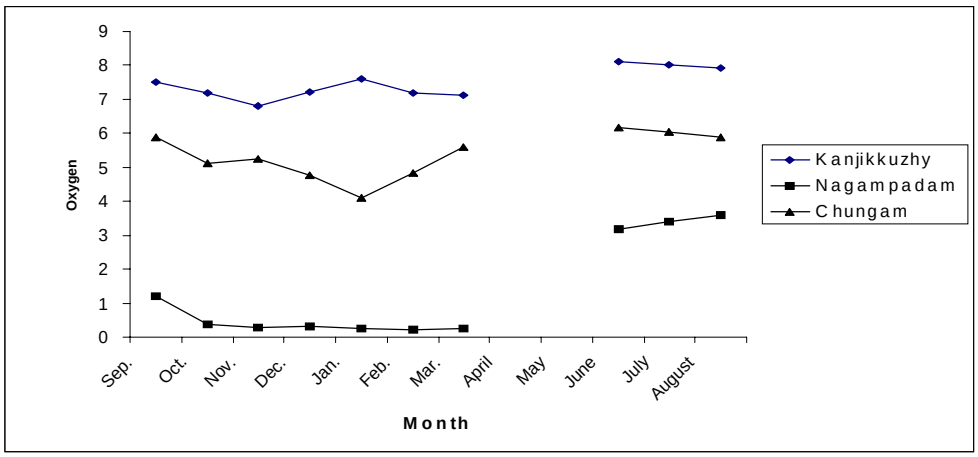
Dissolved oxygen ranged between a minimum of 0.21 mg/l and a maximum of 8.10 mg/l. When repeated, dissolved oxygen was found highest in the water body with clear water and the lowest in the polluted water.

According to Goldman and Horn, oxygen dissolved in freshwater and very cold water contains less than 5 per cent of the oxygen contained in a similar volume of air. The amount rapidly decreases as water-temperature rises.

At the beginning of summer, the productivity of the epilimnion increases resulting in a decline of oxygen in the hypolimnion. Moreover, at the end of summer when the hydrophytes die their rapid decomposition may lower the oxygen level (Brewer, 1993). According to Walker (1979), the decomposition of organic matter from natural source, domestic, and

industrial sewage may result in serious depletion of oxygen. When this continues for a long period, most aquatic organisms perish or are replaced by a few specialised organisms tolerant to low oxygen. According to Goldman, water contains little oxygen due to relatively low partial pressure of oxygen in the atmosphere and its low solubility.

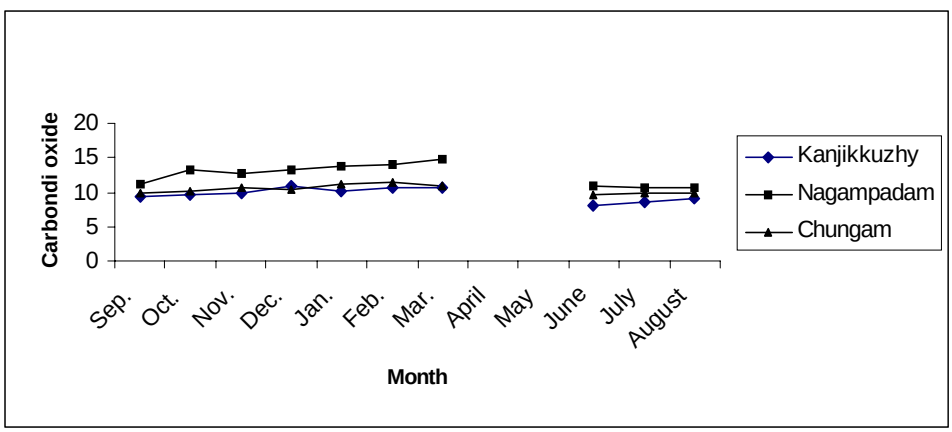
Figure 3.4 Monthly oxygen levels in three water bodies: September 1997 - August 1998



Carbon-dioxide

The carbon-dioxide value ranges between 8.18 mg/l and 14.7 mg/l. There is very little fluctuation in Co_2 level in the three water bodies. It is the highest in the polluted water body. Though only a minor component of air, carbon dioxide is fairly abundant in water because its solubility is about 200 times that of oxygen (Talling, 1976). According to Jaffries, carbon dioxide is more soluble in cooler waters.

Figure 3.5 Monthly carbon dioxide levels in three water bodies: September 1997 - August 1998

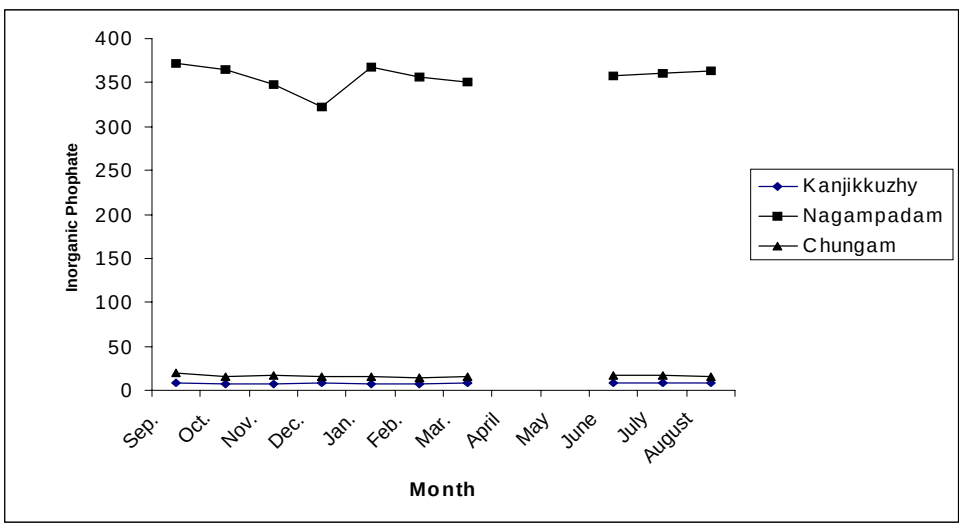


While the Co_2 tension within the natural waters and within the atmosphere constantly tends towards equilibrium, circumstances prevailing in water like slow diffusion, rapid production of carbon dioxide, insufficient agitation of water, etc., upset this balance. The carbon dioxide content in water is depleted by photosynthesis and lime-depositing bacteria. The rates of some developmental and metabolic processes are increased at higher concentrations of carbon dioxide and are decreased at lower values. Another influence of carbon dioxide as an environmental factor is in relation to orientation. The movement of certain aquatic animals is affected by differences in concentrations of gas.

Inorganic Phosphorus

The level of inorganic phosphorus is very high in the highly polluted water-body (Nagampadam) and low in the other two (Chungam and Kanjikkuzhi).

Figure 3.6 Monthly inorganic phosphate levels in three water bodies: September 1997 - August 1998



Hardness of water

Hardness is now defined as the sum of the Calcium and Magnesium concentration, both expressed as calcium carbonate in milligrams per litre. The values are low in the water bodies at Chungam and Kanjikuzhi but fairly high in the water body at Nagampadam, which contains polluted water.

Calcium

Calcium is the fifth among elements in order of its abundance and presence in water. In urban areas, the supply is mainly from sewage water and organic waste. It is high in the polluted water at Nagampadam and low in the other two.

Figure 3.7 Monthly levels of hardness of water in three water bodies: September 1997 - August 1998

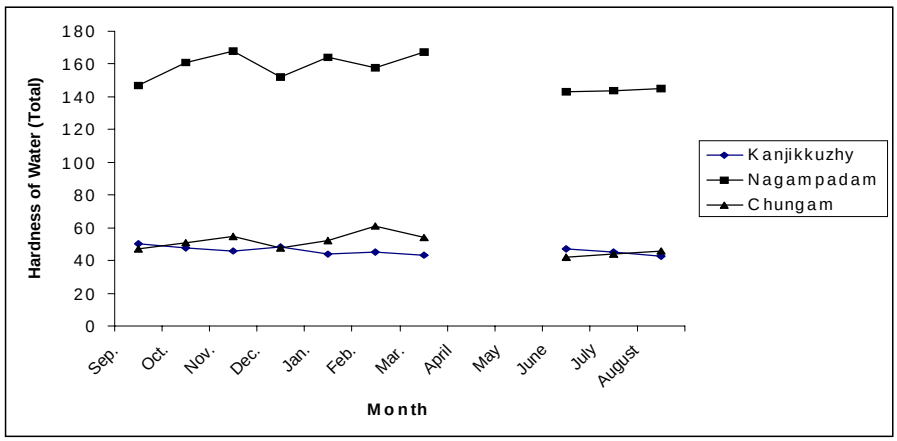
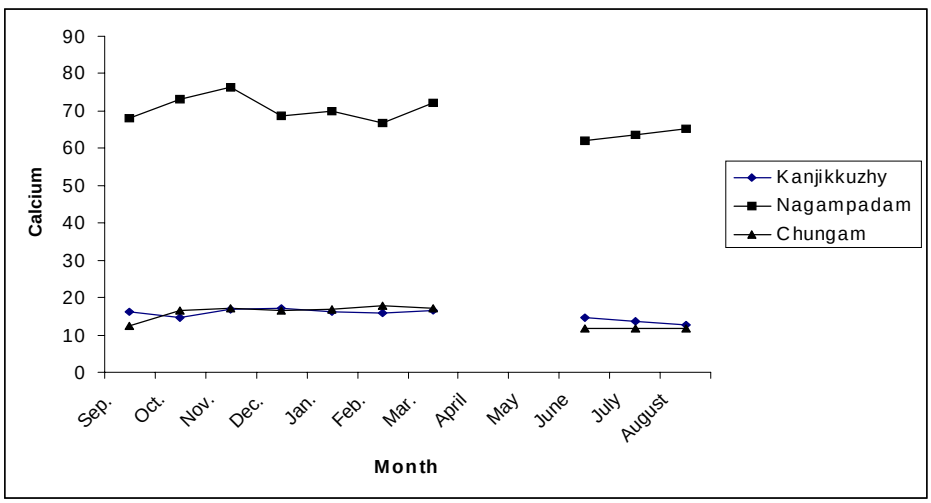


Figure 3.8 Monthly levels of calcium in three water bodies: September 1997 - August 1998



Magnesium

Magnesium ranks eight among the elements in order of abundance and is a common constituent of natural water. As expected, the value is high in the polluted water at Nagampadam and low in the other two. Magnesium concentrations may vary from zero to several hundred milligrams per litre depending on the source of the water.

Chloride

Chloride, in the form of chloride (Cl^-) ion is one of the major inorganic anions in natural and

wastewater. It ranges in the study area between 4.24 and 10.21 mg/l. Chloride concentration is thus higher in wastewater than in raw water.

Figure 3.9 Monthly levels of magnesium in three water bodies: September 1997 - August 1998

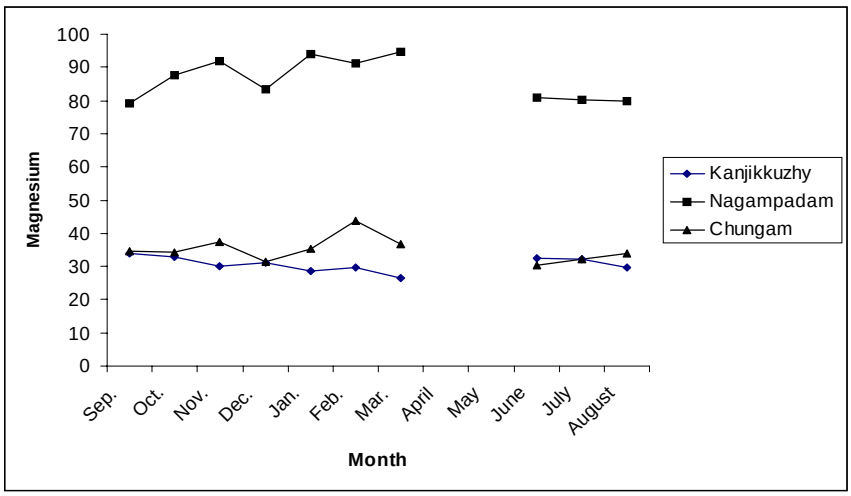
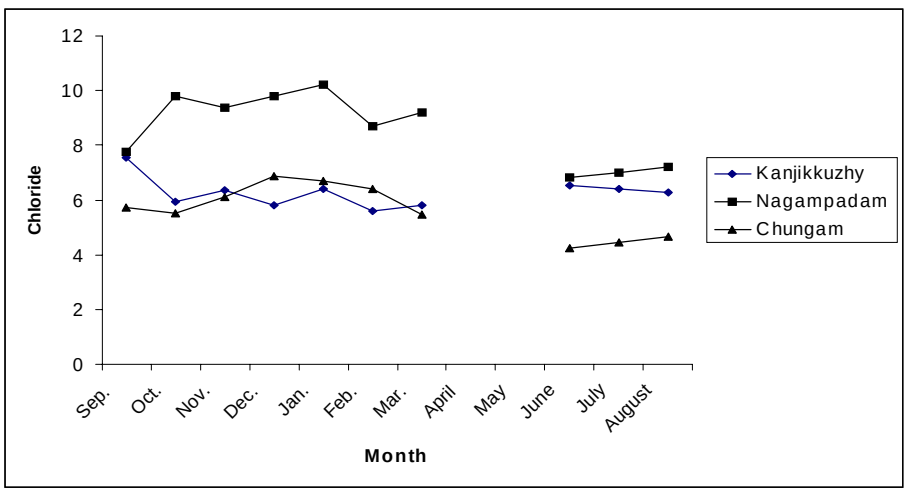


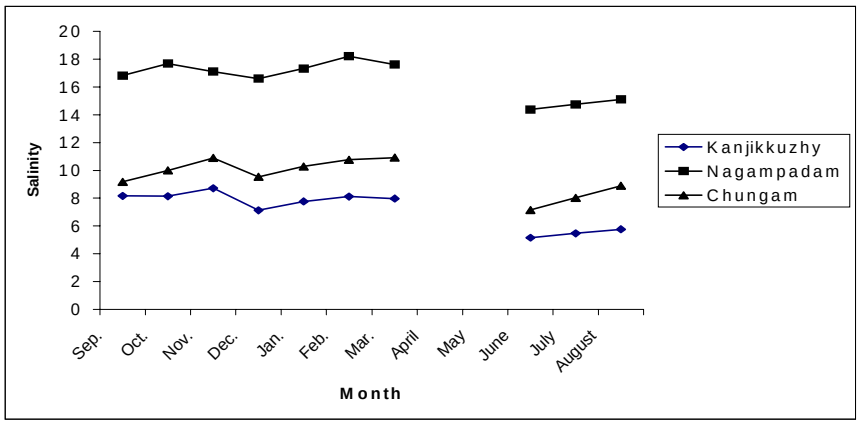
Figure 3.10 Monthly levels of chloride in three water bodies: September 1997 - August 1998



Salinity

The salinity in the water-bodies ranges between 7.14 mg/l and 18.21 mg/l. The fluctuation in salinity is low in all the three water bodies. The level is higher in the polluted water-body than in the other two. Salinity decreases with increase in concentration of dissolved gases (Welsch, 1952).

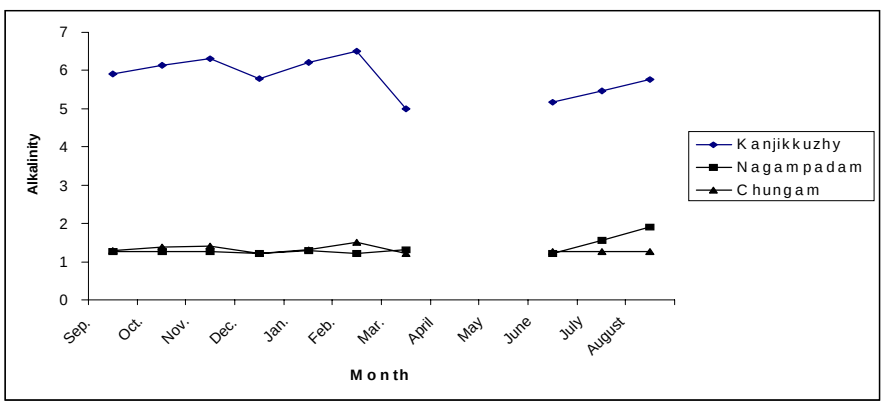
Figure 3.11 Monthly levels of salinity in three water bodies: September 1997 - August 1998



Total Alkalinity

Alkalinity of water is its acid-neutralising capacity. Alkalinity is significant in many uses and treatments of natural waters and wastewater. Because alkalinity of surface-waters is primarily a function of carbonate, bicarbonate, and hydroxide content, it is taken as an indicator of the concentration of these constituents. In the study areas it varies between 1.2 and 6.5 mg/l. It is high at Kanjikuzhi and low in the other two.

Figure 3.12 Monthly levels of total alkalinity in three water bodies: September 1997 - August 1998



Biological Parameter

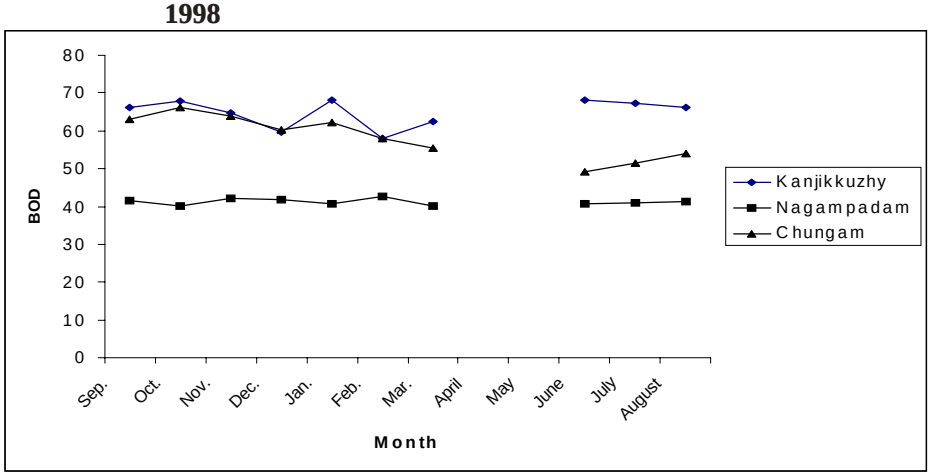
BOD

The most widely accepted measure of water pollution is the Biological Oxygen Demand

(BOD) value. The BOD of the water bodies surveyed ranges between 40.13 and 68.24. It is low in the highly polluted water body (Nagampadam). It is higher in the other two. Between them the difference is marginal.

BOD refers to the amount of O_2 needed to breakdown or oxidise organic materials to Co_2, water, and minerals by the micro-organisms in water. Owing to addition of sewage and waste, dissolved oxygen (DO) levels are depleted in water, a fact that is reflected in terms of increasing BOD values of water. The number of microbes also increases tremendously, thus increasing the consumption of oxygen.

Figure 3.13 Monthly BOD values in three water bodies: September 1997 - August 1998



Biota

Most minor water-bodies are ponds that have certain special characteristics (Jeffries and Mills). Most of them are artificially made for different purposes, like effluent settling, quarry-work and digging for construction. Their large number but small size results in variables colonisation and annual perturbations causing very variable communities. Many are transitory, ephemeral habitats with an unusual, specific biota that does not occur elsewhere. The biota of a pond includes flora and fauna. The water-bodies studied in Kottayam municipality area contain in varying degrees most of the common biota occurring in ponds.

Flora

The plants usually found in these minor water-bodies may be classified on different bases. One basis is the position they occupy in the water-body. From this point of view they are classified into the following categories:

Emergent Vegetation

This type includes rooted plants like Ipomoea, Jussiaea, Typha or cat-tails. Scirpus (bulrushes) (arrowheads), Phragmites, Acorus, Vernonia, Nymphaea, Pistia, Colocasia, etc.

Rooted aquatic vegetation recovers nutrients from the deep sediments and provides a 'nutrient pump'. They form a link between the water and the land environment. They also provide food and shelter for aquatic and amphibious animals.

Floating vegetation

This includes Nymphaea, Pistia, Salvinia, Eichhornia,and Wolffia. Their broad leaves reduce light penetration into the water but provide convenient places for animals to rest and lay eggs.

Submergent Vegetation

This includes rooted or fixed plants, which remain completely submerged in water. Their leaves are thin and finely divided, and are adapted for exchange of nutrients with water. Examples are Vallisneria, Hydrilla, Chara, Potamogeton, Utricularia and Ceratophyllum.

Phytoplankton

This includes several species of filamentous algae like Spirogyra and Oedogonium, Volvox, Oscillatoria, Anabaena, Eudorina, Closterium, Diatoms, and Navocula.

Fauna

These may also be classified on different bases. On the basis of the position they occupy in the water-body, they can be classified into the following types.

Zooplankton

They float on the surface and usually have floating devices.Eg. Dinoflagellates, Brachionus, Bosmina, Copepods, Hetrozoans, Ostracods, Colonial Rotifers, and Water beetles.

Nekton

Organisms, which are actively moving and have definite locomotor organs, are included in this category.Eg. Paramecium, Euglena, dipteran larvae, pupae, insects like Dytisscus, Ranatra, and Corixa.

Periphyton

These are organisms found among the rooted plants.Eg. Pulmonate pond-snails, nymphs of Dragon fly, May-fly, Caddis fly, rotifers, flatworms or planarians, freeliving roundworms, Hryozoans, Hydra, larvae of midgets and mosquitoes, crustaceans like Macrobrachium, Caridina species, and water-mites, and Annelids like leeches.

Benthos

Organisms, which live at the bottom, come under this type. They may crawl or remain

attached to the bottom. Eg. decomposing bacteria, planarians, bivalves, fishes like Anabas, Ophiocephalus, and Saccobranchus.

Edge-dwellers

These are usually amphibious forms. Eg. Birds like kingfisher, Herons, Egrets, ducks, water hens, frogs, snakes like Natrix, mammals like Rats and Mongoose.

4. Summary and Conclusions

Kottayam town is described as the town of letters, lakes, and latex. The present study has revealed that about one-third of the municipality area is covered by minor water bodies. They range in size from 1.5 sq.m to 1000 sq.m. The water in these bodies collects from different sources like direct rainwater, flood over flow from the surrounding areas, sewage water from neighbouring houses, and city drainage canals.

Out of the 48 ponds surveyed 23 have inlets. These water bodies receive water from the municipality sewage canals, shops, markets, nearby houses, factories, etc. These water bodies are highly polluted. The rest of the water bodies have no inlets. Fifteen receive garbage, which is dumped directly into them. About 75 per cent of the water bodies get flooded during the monsoon. Hence these water bodies also get polluted by the pollutants carried in by the floodwater. Timber, tiles, and latex factories also dump their wastes in these water bodies. The water bodies are used also as sinks for dumping wastes wherever possible. Public awareness about the importance of the water bodies and the effect of pollution on them is very low. These polluted water bodies act as ideal breeding grounds for mosquitoes and pathogenic micro-organisms. The atmosphere around these water bodies also becomes polluted and emits an obnoxious odour. These water bodies also disfigure the town's landscape.

Six of the water bodies contain muddy water, which is not, however, highly polluted. Thirteen of the water bodies contain fairly clean water.

Water is a natural resource used for a number of anthropogenic activities. The amount of water required by the inhabitants of Kottayam municipality increases day by day, due to increase in population, industrialisation, urbanisation, etc. Kottayam municipality, like most other towns in the world, is facing water scarcity. This problem can be reduced to a certain extent by making use of water in the minor water bodies. The water bodies containing muddy water could be used for bathing domesticated animals; and the ones containing clear water could be used for washing, bathing, etc. With a little amount of care and maintenance more number of water bodies could be brought under use for human activities. Public and government involvement would be required for making them usable.

None of the water bodies are being used for the drinking purpose though all of them could be brought under the economically important purpose. Only 15.36 per cent of the water bodies are now being used for fish culture. Fish culture would also serve as an incentive for the preservation and conservation of the water bodies. In addition to edible fishes, larvivorous, ornamental fishes may also be cultured in them. More water bodies could be brought under fish culture too. The larvivorous fishes would greatly help control of mosquitoes; ornamental fishes could be sold as aquarium fishes. The fishes would also help conversion of the excess organic waste accumulating in the water bodies and thus reduce eutrophication that leads to over-growth of weeds like Salvinea and Eichornia. The frog population would also increase, leading to further decrease of mosquitoes.

The water bodies occupy an area of 5.33 sq. km, which is about one-third the total area of Kottayam municipality. This means that a large quantity of water is being exposed to the

action of sunlight and micro-organisms, thus undergoing purification with no economic input. However, the area of water bodies is undergoing rapid reduction.

Observation of the minor water bodies indicates the presence of a number of organisms. A complete in-depth study of the biota was not possible within the scope of the present project. However, it is obvious that the water bodies harbour a wide range of organisms. The isolated water bodies with fairly clear water would contain unknown species. Aquatic insects, plants, slugs, frogs, tadpoles fishes, larval forms, and micro-organisms like paramecium are being used by the zoology and the botany departments of the College in Kottayam for conducting practical and research activities. The water bodies themselves are used for ecological and environmental biology studies and analysis.

The survey has clearly revealed the fact that the water bodies help in mitigating floods. During the monsoon the excess water flows into these water bodies and from them into streams and the river through various outlets. In areas in which water bodies have got silted up, the surrounding areas experience higher levels of water during the rainy season. The public and the municipality turn a blind eye to this problem; by the time they wake up, it may be too late. Land is being reclaimed at a rapid rate. For example, a major part of the pond No: 35, behind CMS College has been filled up for building a sports complex, during the period of the present survey. In Kodimatha area, houses are now being constructed on large concrete pillars to avoid floodwater entering them.

Not much thought is being given to the fact that the water bodies help in the dispersion of erosive forces. A large quantity of top soil is annually washed away. Run off distances could be reduced by the water bodies and some of the soil reclaimed.

Water in Pond No: 26 owned by Vayaskara Vaidyasala (pharmacy) was used in earlier periods for preparation of Ayurvedic medicines. Special efforts have to be made to regenerate the pond and to make its water reusable for this traditional purpose.

Pond No: 21 has a special filter mechanism. The water is thus purified and used with no human effort. The public here takes interest in the maintenance of the pond. It should serve as an example for others to follow.

Ponds No: 11, 17, 36 – 41 and 48 are definitely the result of human endeavour. More water bodies can be artificially created according to requirements and water availability, after careful planning and lay out of the Kottayam town.

At present only two of the ponds, both privately owned, have been beautified as part of the town maintenance and beautification scheme like beautification of the municipal parks.

Utilisation of project output

The information gathered on minor water-bodies in Kottayam municipality area may be used, for a number of purposes, in the planning of Kottayam Town.

The sewage canals and industrial waste of the town could be channelled into the water bodies that already have inlets and outlets of running water like Karapuzha *thodu*, Kodoor River and Meenachil River. Such inlets and outlets could also be artificially constructed for the other water bodies, wherever required. Water quality improvement would thereafter take place without any economic input and pollution of the running water sources like rivers would be greatly reduced.

Proper diversion of water in low-lying areas into deep-water bodies would help minimise flooding. Such water bodies may also be artificially constructed also in other low-lying areas.

In wards facing water shortage, it is possible, with a little planning and care, to maintain water quality of a high standard in the minor water bodies, of a quality that permits water to be used for domestic purposes. The water bodies would also help recharge groundwater. The effect of erosive forces could be reduced by bringing down the run-off distance.

At present, only 15.36 per cent of the water bodies are being used for fish-culture. All the water bodies, except the very highly polluted ones, may be used for this purpose. If larvivorous fishes are also cultivated, mosquito control can also be achieved.

The biota of the pond in addition to performing their natural role of bio-geo-chemical recycling, being part of the food chain, gene pool, etc., could also be used by schools and colleges as biology teaching material and for research purposes.

At present only .05 per cent of the water bodies have been aesthetically constructed. A concerted effort would turn all the water-bodies into things of beauty and turn Kottayam town into an attractive place.

The greatest task in improving the water bodies would be to generate public awareness and interest, including interest of the municipality. The media have an active role to play in generating and fostering this awareness.

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