CHAPTER 8

SUMMARY AND CONCLUSION.
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8.1. Introduction

An investigation on the dynamics and water quality of the Muvattupuzha river in relation to the water resources planning, with special emphasis on the discharge of effluents from Kerala Newsprint Factory was carried out. Fortnightly surveys of the water quality parameters were carried out at seven stations in a reach of 16 km of the river from November 1980 to middle of March 1982, prior to the commencement of discharge of effluents. Studies were also made on the flow characteristics of the river. Two field experiments were conducted to understand the dispersion pattern at the region of the outfall. Since the commencement of the effluent discharges from middle of March 1982, more detailed surveys were carried out in the river reach under study, with more number of stations. On two occasions, the downstream river stretch was severely polluted owing to strong effluent discharge. The study covers the period upto September 1982 (Annexure II). The organic waste loading capacity of the river was determined with the aid of the oxygen sag equations and the model was verified.
8.2. The river regime and water resource projects

The river regime located in the south central part of Kerala is of significant importance with regard to water utility and transporting facilities. The eastern portions of this river basin are high lands. The slope of the river is steep in this region and its width is comparatively small. In the mid-lands three tributaries join together. In the low lying regions (around MSL) the typical riffle-pool sequence is observed. A few deep pools are located near the river mouth. The climatic conditions favour one peak discharge period in June-July months followed by an irregular secondary peak in October. The catchment area of 1554 km$^2$ enjoys on an average 300 cm of annual rainfall. The west-ward flowing river has two outlets into the Cochin backwaters. Saline waters (5-15%) used to enter the river during February-April months due to tidal action till 1976.

The lowest discharges (4 to 7 m$^3$/sec) in the Muvattupuzha river occurred during February which increased to about 300 m$^3$/sec during June-July. But from late 1976 onwards the river flow conditions drastically altered subsequent to the discharge of tail race waters from Moolamattom power station (19.83-78.50 m$^3$/sec). Since then the minimum discharge (February-April) is $\approx$ 50 m$^3$/sec.
water incursions into the river are no more observed.
The effect of tides is limited to periodic rise and fall
of water level in the lower reaches of the river with no
upstream currents. The river water serves all the
requirements of the locality and is utilised for agriculture, domestic purposes, recreation etc.

Subsequent to the construction of Idukki reservoir
and Moolamattom power station, water resources programmes
were aimed at utilising a major portion of the tail race
discharges for agricultural purposes. Towards this a
balancing reservoir has been constructed at Malankara to
divert water at the rate of 33.58 m³/sec. Under the
present conditions, this would cause considerable
reduction in the flow downstream resulting in the development
of tidal currents inside the river. The salt water
intrusions may lead to alterations of the fluvial ecosystem.

8.3. Industrial unit

The factory located at Velloor on the bank of the
river is 12.5 km upstream of Murinjapuzha river mouth. The
newsprint mill of Hindustan Paper Corporation of 400 tonnes
production capacity deploys a combination of chemi-mechanical
and chemical pulping. The conventional sulphite process
is adopted in this factory also. The mill requires water upto 1.5 m$^3$/sec (taking into account the principal and supporting demands) which is drawn from the Muvattupuzha river. The factory discharges treated effluents into the river just downstream of Piravom Road railway station. The treatment system mainly consists of a clarifier, a cooling pond (presently used as a sedimentation pond) and aerated lagoons (total aerators 16 numbers). The system is purported to be capable of purifying the effluents to a level below the limits laid down by the Pollution Control Board. Details of the treatment system are given in Annexure I.

8.4. Water quality

The results of the studies on the quality of the river water, effluents and the water after receiving effluents are presented in table 11.

The water quality prior to effluent discharges indicates good potable water of high standards. The water is nearly saturated with $\Omega$ (6.0 to 11.5 mg/l) and pH lies within 6.85 to 7.20. Amount of suspended solids are low (2 to 30 mg/l) and $\text{BOD}$ values are between 0.5 and 3.0 mg/l. The nutrient content is generally low and amount of mercury in river water is 0.0005 mg/l or less which lies
### Table 11. Results of investigations on water quality.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Ambient water quality</th>
<th>Effluent quality</th>
<th>River water quality after receiving effluents</th>
<th>Tolerance limit (Indian Standards)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General appearance</strong></td>
<td>Calm flowing river, no presence of oil, tar etc.</td>
<td>Foaming, soapy appearance, Presence of oil and grease</td>
<td>Foam forming tendency, Presence of oil and grease in patches</td>
<td>26-30°C</td>
<td>Preferably palatable.</td>
</tr>
<tr>
<td><strong>Colour</strong></td>
<td>No noticeable brown colour (&lt;40 Hazen units)</td>
<td>Brown to dark brown (50-150 Hazen units)</td>
<td>Brown bands and patches visible (max. 210 Hazen units)</td>
<td>River water colour +100 Hazen units</td>
<td>River water should not be objectionable.</td>
</tr>
<tr>
<td><strong>Taste</strong></td>
<td>Palatable</td>
<td>Highly objectionable.</td>
<td>Disagreeable</td>
<td>Water should be clear, and hygienic.</td>
<td></td>
</tr>
<tr>
<td><strong>Odour</strong></td>
<td>Slightly vegetable</td>
<td>Musty and organic (Persisting smell of mercaptans)</td>
<td>Not highly objectionable</td>
<td>Should give a healthy appearance.</td>
<td></td>
</tr>
<tr>
<td><strong>Transparency</strong></td>
<td>Low extinction (Extinction Coefficient (1.14-2.0)</td>
<td>High extinction Coefficient (2-4)</td>
<td>Water should be clear, and hygienic.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Temperature (°C)</strong></td>
<td>25.5-30</td>
<td>30-31.5</td>
<td>26-30.5</td>
<td>Preferably ambient.</td>
<td></td>
</tr>
<tr>
<td><strong>Solubility (%)</strong></td>
<td>Freshwater conditions observed throughout.</td>
<td>No salt water incursions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>6.85-7.20</td>
<td>5.80-6.35</td>
<td>6.25-7.85</td>
<td>Potable range 6.5-7.8</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
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<th>River water quality after receiving effluents</th>
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<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>6.0-11.5</td>
<td>0-7</td>
<td>5.5-10.0</td>
<td>40% of saturation value or 3 mg/l which ever is higher</td>
<td>River water DO not lowered below tolerance limit. Effluent quality however does not conform to standards.</td>
</tr>
<tr>
<td>Biochemical Oxygen demand (mg/l)</td>
<td>0.5-3.0</td>
<td>10-5000</td>
<td>1.5-50</td>
<td>¥ 30</td>
<td></td>
</tr>
<tr>
<td>Nutrients (µg at/l)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Presence of excess nutrients may cause eutrophication. Presence of blue-green algae noticed in lagoons.</td>
</tr>
<tr>
<td>NO₂⁻N</td>
<td>0.025-0.09</td>
<td>Not analysed</td>
<td>0.30-0.50</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>NO₃⁻⁻</td>
<td>0.100-1.00</td>
<td></td>
<td>6.00-10.00</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>PO₄⁻⁻</td>
<td>0.100-0.33</td>
<td></td>
<td>0.65-1.25</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Suspended solids (mg/l)</td>
<td>2-30</td>
<td>40-4500</td>
<td>50-140</td>
<td>¥ 100</td>
<td></td>
</tr>
<tr>
<td>Total organic carbon (%) in sediments</td>
<td>0-1.5</td>
<td></td>
<td>1.5-9</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Mercury (mg/l) in river water</td>
<td>0.0005</td>
<td>0.002-0.08</td>
<td>0.0012-0.05</td>
<td>0.01 for effluents, 0.0003 for drinking water</td>
<td></td>
</tr>
</tbody>
</table>
close to the tolerance limit of 0.0003 mg/l. The river water presents a very healthy appearance and is used for all domestic and agricultural purposes.

The studies on the quality of river water after receiving the effluents indicate that the water has been considerably polluted downstream of the outfall. The effect is significant for a few km (≈7 km) downstream of the outfall. Partial recovery is achieved further downstream. Colour, suspended solids, nutrients, organic carbon and mercury were studied to estimate the alterations of the river water quality.

The discharge of effluents of colour brown to dark brown imparting an unpleasant shade to river water gives a very unhealthy look. Though colour is not a pollutant by itself, it may be construed as an indicator of the ineffectiveness of effluent treatment and mostly appeals to the aesthetic values. Presence of oil, grease, floating particles of pulp fibres and frequent appearance of froth and disagreeable taste have been noticed downstream of the outfall. Transparency of the river water was also affected adversely. The pH of the discharge waste water varied between 5.80 and 8.35. The variations in pH were noticeable over long reaches of the river. The DO content of effluents
On many occasions the DO was lower than 3 mg/l or 40% of the saturation value. However the DO in river water was never lowered below the tolerance limit. The BOD of the effluents varied between 10 mg/l and 5000 mg/l. The high BOD value of discharged wastes do not conform with standards laid down by the Pollution Control Board. The river water BOD varied between 1.5 mg/l and 50 mg/l after receiving the effluents.

The factory effluents also contained large amounts of nutrients and suspended solids. The presence of blue-green algae was frequently observed in the treatment lagoons and in discharged waters. Excess nutrients are known to cause eutrophication. The suspended solids in factory effluents were generally higher than the tolerance limit of 100 mg/l. The river water which contained only 2 to 30 mg/l of suspended solids prior to discharge of effluents exhibited values around 50 to 140 mg/l since the discharge started. The solid particles settle on the river bed and are likely to turn into secondary sources for pollution. The organic carbon content of sediments collected from the pools downstream of the discharge point were high (1.5 to 9.0%). Persisting presence of mercury in levels ranging from 0.0012 mg/l to 0.05 mg/l found in the river water during the survey poses a serious
environmental problem. Use of river water contaminated with mercury compounds is highly objectionable. The concentration of mercury has to be limited to levels prescribed by IS:2490 and IS:7968, IS:7967.

8.5. Physiography and flow characteristics

The discharge in the river exhibits a single peak followed by an occasional secondary peak corresponding to the amount of rainfall. The correlation between rainfall and river flow has been discussed in chapter 5 in detail. The effect of tail race discharge since late 1976 is clearly shown at Thodupuzha and Muvattupuzha gauging stations when compared to the long term averages. The studies on the interaction between the tides and river flow indicate that the lower river reach of about 30 km is affected by the tides by way of increase and decrease in river discharge corresponding to the low and high tides. Two situations are investigated in detail and the value of the minimum discharge (30±2 m³/sec) is worked out for a typical tide just to prevent upstream flow at outfall point.

The studies are extended to hypothetical situations and the results of interaction of tides with river discharge are discussed. The implications of the water resources programmes are discussed in light of the tidal behaviour of
the river. The commissioning of the Malankara reservoir will decrease the present discharge in Muvattupuzha river by 60 to 70% resulting in salt water incursions extending up to Pazhur, upstream of the effluent discharge point. In this event, the quality of water may not be suitable for factory requirements and the presence of a two-way flow in the river will cause severe pollution problems.

8.6. Dilution and dispersion

The dispersion pattern at the effluent outfall region was studied by conducting two tracer experiments (chapter 6). The dispersion at the outfall is not effective enough to cause the required dilution of the effluents. The location of the outfall has drawbacks with regard to the upstream slope, back currents and curvature effect apart from the deficiency in design of the diffuser port.

8.7. Waste assimilative capacity

The sag curves for waste loads ranging from 10 mg/l to 5000 mg/l BOD (5 days) (20°C) were derived for minimum river flows caused by the influence of high tides. The effect of imposing a waste load of 500 mg/l BOD resulted in the decrease of dissolved oxygen to values lower than 3 mg/l downstream of the outfall. The relevant standards
dissolved oxygen of the (river) water as 3 mg/l or 40% of saturation value, whichever is higher, after receiving the effluents. The remaining DO in river sags below the tolerance limit for BOD loads equal to or greater than 500 mg/l at points nearer to the outfall. Under the present conditions in order to maintain the entire stretch of the river downstream of outfall well above the tolerance limit for DO, a value of BOD 300 mg/l has been estimated as the maximum assimilative capacity for this river. This value accommodates the changes in hydraulic characteristics of the river and effluents within limits. It may be noted that the above value is worked out assuming instantaneous mixing of effluents with all the available river water and that the reaction is first order. The suggestion of the above capacity value does not imply that the statutory tolerance limit of BOD 30 mg/l enforced by the Water Pollution Control Board can be overlooked. In the long run presence of pools, fresh waste additions, abstraction of water, hydraulic design variations may adversely affect the oxygen balance in the river. The suggested value will no longer hold true, once the diversion at Malankara reservoir reduces discharge in the downstream reaches of the river and a two way flow is established by the tidal fluctuations acting through the Cochin bar mouth.
8.8. Sludge disposal

An impending problem of pollution is connected with the disposal site for sludge material. The location is half way down the effluent pipe line and the place was formerly a paddy field. During monsoon, the entire region is flooded. The observations of the ground wells have shown that the water table slopes from this disposal land towards the river side. The sludge, contains cooling pond waste, organic matter like fibre bits pulping wood chips, cinder ash, lime-mud etc. The sludge material is not given any pre-treatment before disposal and this is likely to cause severe ground water pollution in due course. The fields may turn to be a large pool of decomposing sludge in rain water collections. The possible presence of compounds of mercury is not ruled out in this sludge material. The above practice warrants attention and review.