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AN INVESTIGATION OF THE RIVER GODAVARI AND THE EFFECT OF THE PAPER MILLS POLLUTION AT RAJAHMUNDRY

by

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ABSTRACT

An investigation of the chemistry and biology of the River Godavari in relation to pollution by the effluents of the paper mills at Rajamundry is reported. A description is given of the pollution situation, and an account is given of the biota under natural and polluted conditions respectively. Suggestions have been made for the abatement of this pollution nuisance.

In all industrialised countries of America and Europe, it is not lawful to deposit in or allow to pass into water resources of the State any extraneous matter or any residuary solid or liquid from any refinery, tannery, distillery, chemical works, paper mills and other types of factories, which will be deleterious to fish or plant life. In India, which is fast progressing industrially, many manufacturing undertakings are started near dams, hydro-electric reservoirs and rivers where power and water are available. Factory refuse is allowed to accumulate close to such industrial concerns and to pollute the nearby water resources. As industries and population continue to grow, pollution of water resources by factory wastes becomes an ever-present problem requiring continuous and vigorous attention in view of the need for the conservation of all existing food supplies and the preservation of fish life and other material resources for the benefit of the present and future generations.

In India, Hora (1942) was perhaps the first to draw attention to this serious problem from the fisheries aspect; and Hora and Nair (1944) made a scientific study of the effluents of the Quinine Factory at Mungapoo in Darjeeling, Bengal, from this point of view. Bhimachar and David (1946) studied the effects on the Bhadra river fisheries of factory effluents from the Mysore Paper Mills and the Mysore Iron Works at Bhadravati. Ganapati and Alikunhi (1950) studied the factory effluents from the Mettur Chemical and Industrial Corporation Ltd., Mettur Dam, Madras, and their pollutional effects on the fisheries of the river Cauvery. Factory effluents from the Andhra Paper Mills at Rajahmundry are polluting the river Godavari, causing mortality of fish during the non-flood season (January to June). Since remedial measures should be taken in the interests of preservation of game and food fishes of this river, an investigation of this problem was made from 1946 to 1950. The results of this study form the basis of this communication.

PHYSICO-CHEMICAL NATURE OF THE EFFLUENTS

The wastes discharged from the mills come from (a) the manufacture of pulp from different raw materials, such as bamboos, rags and waste paper, (b) purification of pulp, and (c) the manufacture of craft paper. Each of these processes is carried out in three different sections (Fig. 1).

In the preparation of fibre for the paper, 30% of the pulp used is from bamboos, 10% from rags and 60% from waste paper. The main process of making pulp from bamboo consists of removing the non-cellulose portion like lignin by treatment under pressure with a solution containing 80% caustic soda and 20% sodium sulphide. The waste ligneous liquor, after further treatments for chemical recovery, is very dark in colour and contains sulphides, sulphates, lime, soda and suspended matter. It is lead out separately by a channel and is accumulated in a tank outside the premises of the mills before discharge into the river.

Old gunny bags, rags, etc., are boiled with lime or soda and washed with water, while waste papers are sorted out and kneaded into a pulp with water and steam. These pulpy materials are made ink proof by the addition of rosin and alum. The effluent from the pulp section thus consists of excess water used for washing and screening the pulp. This waste water along with lime sludge of the causticizers goes in a drain, and passes through baffle walls where lime sludge is deposited and then passes out as effluent.

The effluent from the paper section consists of water and minute particles of pulp in suspension. This is taken by a separate drain to settling tanks from which it passes out as a yellowish oily supernatant liquor containing about 0.01% of resin and alum.

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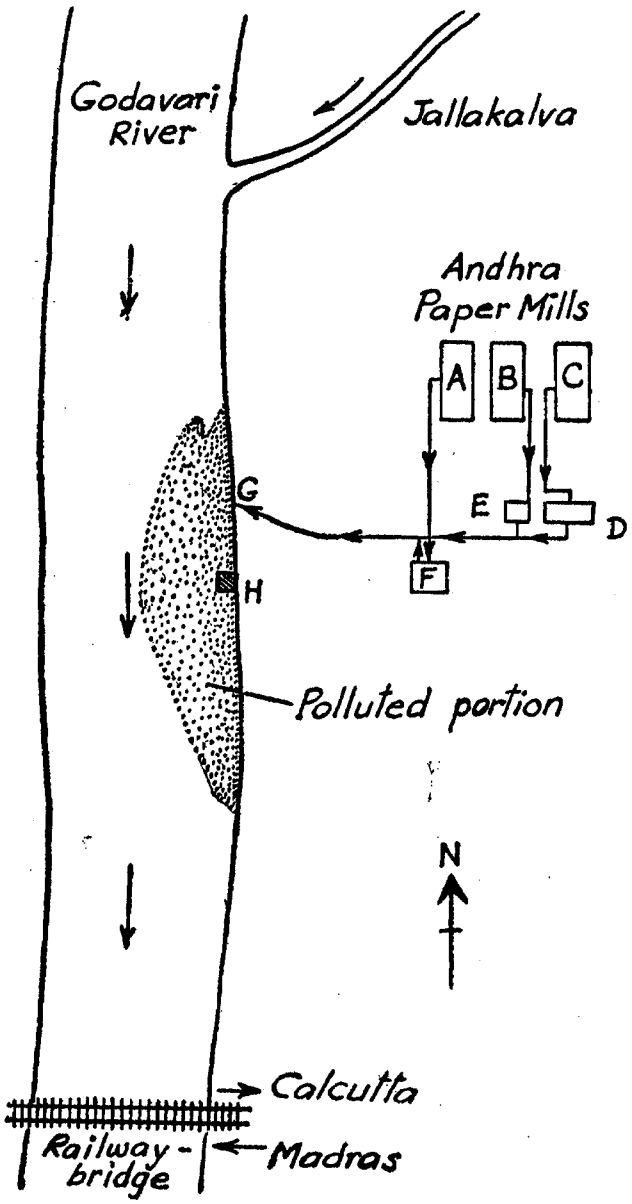

FIG. 1.

DIAGRAM SHOWING GODAVARI RIVER NEAR ANDHRA PAPER MILLS, RAJAHMUNDRY.

A: Raw Materials Section. B: Pulp Section. C: Paper Section. D: Settling Tank for C. E: Settling Tank for B. F: Storage Tank for A. G: Outfall of Common Effluent Channel. H: Intake Tower.

The effluents from these three sections then mix together and flow into the river through an open drain. The total quantity of effluents discharged from the mills in a day is about 60,000 gallons. The results of two typical analyses of the effluents from the three sections and from the final outflow channel are shown in Table I, from which it will be seen that the effluent from the raw materials section is noxious while those from the other two sections appear to be harmless. But the mixture which reaches the river is also harmful as is evident from the results of experiments given in Table II, from which it will be noted that the liquid has the capacity to reduce the oxygen content of stagnant water. Further, similar samples when stored for a week became darker, forming flocculent precipitates and also producing hydrogen sulphide. Similar action is likely to take place if this black liquor is allowed to stagnate in any open place.

CONDITIONS OF EXISTENCE IN THE RIVER GODAVARI

The Godavari river is in flood from July to December and during the rest of the year it contains little water with practically no flow. During flood the river is characterised by great velocity of flow, fluctuating depth and muddy discolouration. During this period it is not possible for the mills' effluents to reach the river by gravitational flow, because the flood water backs up through the outflow discharge channel. It is only when the level of water in the river falls below that of the canal that the effluent is freely discharged into the river. But at this time there is not much flow in the river and therefore proper mixing and dilution of the effluent seems not to take place.

The physico-chemical conditions of the river during the floods (Table III) show that the effluents have no effect on the river during this period. This river stretch has been found by Chacko (1946, 1949), Chacko and Ganapati (1950), and Job and Chacko (1947) to be the spawning and nursery grounds of major carps such as *Catla catla*, *Cirrhina mrigala*, *Labeo fimbriatus*, *L. calbasu*, *L. boga*, *L. ariza*, *Thynnichthys sandkhol* and *Puntius kolus*. Chacko (1947) and Chacko and Ganapati (1949) have observed the Indian Shad, *Hilsa ilisha*, performing its migration through this river stretch.

During the non-flood season (January to June), the river becomes lentic in condition. The level of water gradually goes down because of both evaporation as well as of the draw-off for irrigation purposes. It is during this period that the effluents from the mills cause harm to the fish population within a limit of about 1 mile below the outfall.

A bird's-eye view of the river from the embankment of the river where the effluents are discharged (Fig 1), as on 13th April 1950, presented an interesting sight. For about one mile below the outfall and one furlong above it and about four furlongs towards the middle of the river, the river water was

black in appearance. Beyond this region the water was bottle-green in colour. The black portion was the area affected by the effluents. This dry weather condition continues till the end of June and the area of pollution is thus bound to increase much further within that period.

In the polluted area, soft, fluffy, floating, decomposing, flocs of aluminium hydroxide and organic matter were seen in abundance. Copious gases were also seen escaping from the bottom on probing with a stick. The depth of water in these places was about 4 to 5 feet only. Samples of water taken from these places contain oxygen in fair amounts (5.026 cc/1) while near the outfall it was very low (0.838 cc/1). The other physico-chemical conditions are detailed in Table IV.

Trial nettings with a cast net revealed the presence of small species of fishes such as *Barbus ticto*, *B. stigma*, *Rasbora daniconius*, *Ambassis ranga* and *Glossogobius giuris*, and the prawn *Palaemon malcolmsonii*. Macrovegetation like Hydrilla, Vallisneria and Potamogeton were present only in the sheltered portion just above the outfall. The phytoplankton was represented by few individuals of Myxophyceae (Amphithrix, Merismopedia, Microcystis and Oscillatoria), Chlorophyceae (Cladophora, Cosmarium, Oedogonium, Pediastrum and Penium), Bacillarieae (Amphora, Cymbella, Gomphonema, Navicula, Nitzschia, Surirella, Synedra and Tabellaria) and of Euglenophyceae (Euglena and Phacus). The zoo plankton was represented by rotifers (Brachionus, Euchlanis, Noteus, Notholca, Pedalion, Rattulus and Rotifer) and copepods (Diaptomus and Eucyclops). The bottom fauna consisted of dipteran larvae (Chironomus), worms (Chaetogaster) and gastropods (*Vivipara variata* and *Paludomus stomatodon*). Dead shells of *Corbicula striatella*, *Melania tuberculatus*, *Indoplanorbis exustus* and *Limnaea succinea* were found scattered about at the bottom.

The physico-chemical conditions of the non-polluted portion of the river is given in Table IV, from which it will be seen that in this region the water is not only bottle green in colour, indicating the presence of phytoplankton, but is also highly alkaline (pH : 8.5) and highly oxygenated (85 to 93% saturated). The plankton was rich and varied and consisted of Myxophyceae (Amphithrix, Anabaena, Merismopedia, Oscillatoria and Tetrapedia), Cyanophyceae (Coelastrum, Closterium, Cosmarium, Dictoysphaerium, Euastrum, Genicularia, Golenkinia, Gonatozygon, Oocystis, Pandorina, Pediastrum, Penium, Pleurococcus and Sphaerocystis), Bacillarieae (Amphora, Cymbella, Eunotia, Gomphonema, Gyrosigma, Navicula, Surirella and Synedra), Dinophyceae (Glenodenium), Euglenophyceae (Euglena), Rotifera (Brachionus, Euchlanis and Notholca), Cladocera (Diaphanosoma, Alonella, Simocephalus, Daphnia and Bosmina), Ostracoda (Cypridopsis), Copepoda (Diaptomus and Eucyclops). The bottom fauna was also rich, and consisted of Pelecypoda (*Lamellidens marginalis* and *Corbicula, striatella*) and Gastropoda (*Melania tuberculatus, Indoplanorbis exustus, Vivipara variata* and *Paludomus stomatodon*). The catches of fishermen who were operating in the river at the time of investigation were examined and found to consist of a variety of species such as *Wallago attu, Pseudotropius taarkee, Mystus aor, M. seenghala, M. cavasius, Labeo fimbriatus, Cirrhina reba, C. mrigala, Catla catla, Thynnichthys sandkhol, Amblypharyngodonmola, Barbus sarana, B. stigma, Rasbora daniconius, Chela bacaila* and *Rohtee cotio*. Prawns such as *Palaemon malcolmsonii* and *P. scabriculus* were also present.

PHYSIOLOGICAL RESPONSES OF FISHES TO DIFFERENT CONCENTRATIONS OF THE EFFLUENT

Laboratory experiments were made to study the response of *Barbus stigma* to the effluents. It was found that this species died immediately when placed in the black effluent from the raw materials section, and survived for only 15 minutes in the effluent from the pulp section and for three hours in the effluent from the paper section. In the mixture of effluents discharged into the river it died within half hour. By further experiments it was ascertained that the fish survived for several hours in a dilution of one part of the effluent to 500 parts of freshwater.

DISCUSSION

There is no doubt that the effect of the effluent from the Andhra Paper Mills is harmful to both fish life and fish food organisms. The effluent is black and offensive, reduces oxygen content of water and generates hydrogen sulphide. There is also deposition of aluminium hydroxide flocs with organic matter covering the river section near the mills, owing to the presence of alum in the effluents. A marked difference is noticeable between the polluted and non-polluted section of the river, the latter being characterised by optimum hydrobiological conditions which are suitable for supporting a rich fish fauna. It has been experimentally determined that a minimum dilution of 1 : 500 is necessary for safely letting the effluent from the mill into the river. It has been suggested to the authorities of the mills that the effluents should either be pumped into the river only when the latter is in high floods or that they should be purified

by some sort of rough and rapid filtration through sand before being discharged into the river.

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SUMMARY

The Andhra Paper Mills situated on the left bank of the Godavari river near Rajahmundry, discharge about 60,000 gallons of its effluents into the river per day during the non-flood season. These effluents are noxious, being black and offensive, reducing the oxygen saturation of the river water. Flocs of aluminium hydroxide form and cover the surface and bottom of the river in the vicinity. The hydrobiological conditions of the river during the flood and non-flood season in the polluted and non-polluted regions were studied. The oxygen content near the outfall of the effluents was as low as 0.838 cc/1. Fish life was represented by a few small species. The plankton and the bottom fauna were also poor. On the other hand, the conditions were satisfactory in the non-polluted area, which was rich in plankton, bottom fauna and fish life. Laboratory experiments showed that dilution to 1 : 500 is necessary to prevent the deleterious effect of the effluents. Suggestions for the disposal of the effluents have been made.

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TABLE I

Showing results of analyses of physico-chemical conditions of effluents from the Andhra Paper Mills, Rajahmundry

Description	Raw materials section		Pulp section		Paper section		Mixture of all effluents
	23-10-46	13-4-50	23-10-46	13-4-50	23-10-46	13-4-50	23-10-46
Colour ..	inky	pitch dark	brownish	yellowish	yellowish	dirty yellows	dark brown
Turbidity—cm. ..	0.0	0.0	6.5	10.4	19.5	10.0	10.0
Time ..	1.0 p.m.	9.25 a.m.	12.15 p.m.	9.5 a.m.	12 N	8.55 a.m.	12.20 p.m.
Temperature—°C ..	45.0	31.4	40.4	40.9	37.9	41.1	39.1
Free Co_2 pp, 100,000	H_2S	H_2S	nil	..	0.431	..	nil
CO_3 ,, ..	smelling	smelling	9.0	..	..	..	2.25
HCO_3 ,, ..	..	..	7.930	..	10.938	..	11.742
Chloride ,, ..	..	..	2.9	2.0	2.3	2.08	2.5
pH ..	6.0	6.0	9.4	6.4	7.3	6.5	8.5
Dissolved o_2—cc/1 ..	nil	nil	1.628	..	3.165	..	2.442

TABLE II

Showing oxygen consuming capacity of the effluent of the Andhra Paper Mills, Rajahmundry

Ratio of effluent to tap water	Dissolved oxygen in cc. per litre in 3 minutes at laboratory temperature.
(1) Tap water only (control)	2.059
(2) 1 cc. of effluent in 250 cc. of tap water	1.326
(3) 5 cc. ,, ,,	0.977
(4) 10 cc. ,, ,,	0.488
(5) 20 cc. ,, ,,	0.349
(6) 40 cc. ,, ,,	Nil

TABLE III

Showing physico-chemical conditions of river Godavari during the flood season

Description	Below railway bridge	Opposite effluent outfall	Opposite Jallakalva.
Date	17-7-1948	17-7-1948	17-7-1948
Time	8.30 A.M.	12.10 P.M.	5.30 P.M.
Colour	brownish	brownish	brownish
Turbidity—cm.	2.0	2.0	1.5
Temperature oC	29.1	30.1	29.1
Free CO_2, pp. 100,000	2.24	nil	nil
CO_3, ,, ...	nil	1.2	0.9
HCO_3, ,, ...	15.555	7.930	6.405
pH	7.3	7.8	8.3
Dissolved O_2, cc/1	3.065	4.126	4.876
%saturation	54.6	74.7	86.4
Chloride, pp. 100,000	1.4	1.2	1.0

TABLE IV

Showing physico-chemical conditions of the polluted and non-polluted stretches of river Godavari, as on 13th April 1950.

Description	Polluted area			Non-polluted area		
	Near outfall of effluent	One furlong below outfall	Near intake tower	Four furlongs in front of outfall	6 furlongs in front of outfall	One mile below outfall
Time	10.5 a.m.	10.20 a.m.	11.0 a.m.	10.30 a.m.	10.50 a.m.	11.10 a.m.
Colour ..	deep brown	deep brown	brown	dirty green	bottle green	greenish
Temperature—oC ..	39.1	32.4	30.9	30.6	30.4	30.6
Free CO_2, pp. 100,000	0.502	0.495	..	..	..	..
CO_3, ,, ..	nil	nil	0.590	0.886	0.886	0.886
HCO_3, ,, ..	19.505	20.707	16.806	17.106	16.505	16.505
pH ..	7.7	7.6	8.45	8.5	8.45	8.45
Dissolved O_2, cc/1 ..	0.838	1.326	4.886	4.706	5.165	5.026
% saturation ..	..	..	88.9	85.3	93.2	91.1
Chloride, pp. 100,000	..	3.4	3.2	3.3	3.3	3.0
Phosphates ($_2Po_5$) ,,	..	trace	trace	trace	trace	trace
Silicate (Sio_2) ,, ..	..	1.1	1.3	1.2	1.3	1.3