CALCUTTA SEWAGE AND FISH CULTURE.

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History of Calcutta drainage.

The crucial problem which confronts every municipal administration, with the expansion and growth of the city, is the efficient disposal of the city's refuse and drainage. This problem of disposal of Calcutta's drainage has been engaging the attention of the authorities responsible for the administration of the city since the beginning of the nineteenth century and even in the middle of the twentieth century the problem has not been finally solved. In 1803 Lord Wellesley in his famous Minutes assigned chief importance to the improvement of its drainage.

> 'The construction of the Public Drains and Water Course of the Town is extremely defective. In their present state they neither answer the purpose of cleansing the Town nor of discharging the annual inundations occasioned by the rise of the river or by the excessive fall of rain during the south-west monsoon........
> 'The health of the town would certainly be considerably improved by the improvement of the mode of drainage and cleansing the streets. An opinion is generally entertained that an original error has been committed in draining the town towards the river Hooghly.'

The Governor-General after enumerating other defects in the municipal administration appointed a strong Committee to consider and report to His Excellency on the drainage problem, amongst other things, with the following instructions:—

1. To examine the relative level of the drain as compared to the level of the river in the rains.
2. To suggest what description of drains or watercourses would prove most efficient (*a*) to prevent rain water stagnating in Calcutta, (*b*) to cleanse the town.

The proceedings of this Committee are not available, but it is apparent from the results that the special problem of drainage was barely touched when the Fever Hospital Committee began its enormous labour. The Committee after examining several experts came to a decisive conclusion in 1821 that nothing less than an underground system of drainage could be permanently satisfactory in a city so extensive and thickly populated.

It was not, however, till 1855 that Municipal Commissioners recommended the adoption of Mr. Clark's Scheme of underground drainage to the Government. The estimated cost of the scheme was twenty-six and half lakhs of rupees. In 1856 Government appointed a Committee to examine the scheme and in 1857 the scheme with certain modifications was accepted. The estimate for drainage was increased to Rs.34 lakhs and the introduction of a diffused water supply, which was considered absolutely an indispensable adjunct to the satisfactory working of any water-borne system, was estimated to cost eleven and half lakhs of rupees. The scheme was further scrutinised by Messrs. Rendal Brothers, Sanitary Engineers, who gave an alternative scheme for draining into Hooghly. Thanks are,

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however, due to the farsightedness of the Municipal Commissioners, who, after fully considering both the schemes, adopted Mr. Clark's Scheme of combined drainage, *i.e.* disposal of sewage and storm water through the same conduit to the Salt Lake.

It took sixteen years to complete the main sewers of Clark's Scheme and by 1875 38 miles of brick sewers and 37 miles of pipe sewers were constructed.

As the town began to develop very rapidly, its environs had to be incorporated within the municipal limit. These localities consisted of (i) Fringe area on the north bounded by the Circular Road and the Circular Canal, (ii) area to the west and south-west of Tolly's Nullah, *i.e.* Alipore, (iii) area to the east of Tolly's Nullah, *i.e.* present Ballygunge, and (iv) Entally area. By 1906 underground drainage system of the above areas was practically completed with the exception of Fringe area which was completed in 1914-15.

In 1924, Manicktala with an area of 2,200 acres and Cossipore-Chitpore with an area of 2,100 acres were incorporated within the jurisdiction of Calcutta Corporation. Both these areas are still unsewered. A scheme for sewering Cossipore, Manicktala and Tangra (east of Entally) had been prepared in 1932 along with the disposal of additional sewage on account of augmented water supply and a very large volume of storm water which now finds its way into the sewers, due to the city being fully built up and roads being paved with impervious materials. The scheme for disposal of sewage and storm water from the city proper has been executed, but owing to the world war the scheme for sewering Manicktala and Cossipore and Tangra has been kept in abeyance.

The expansion of the drainage system of Calcutta should be very well realised from the following figures of sewage pumped daily:—

Year.	Million gallons per day.
1875	15
1891	24
1914	67
1943	130

OUTFALL.

Sewage and storm water of Calcutta, since the inception of the water-borne drainage system in the city in 1875, used to be discharged in its crude form into the river Bidyadhari about 5 miles to the east of the city. This river being tidal, sewage and storm water used to be stored in large reservoirs about five miles in length and were emptied into the river when the water level went down sufficiently low at ebb. The reservoirs could store up eight hours' accumulation of sewage as well as storm water from the city (at $\frac{1}{4}''$ rainfall per hour). The above system of disposal of Calcutta's sewage and rainfall worked satisfactorily for a considerable period of time without causing any appreciable nuisance by forming sludge banks in the river or causing any harm to the fish life in the same.

In the year 1904 the first note of warning was sounded by Mr. Horn, the Engineer of the Irrigation Department, Government of Bengal, authority responsible for the maintenance of the river, that Calcutta's drainage outfall was being seriously threatened as the river at Bamanghata, only 2 miles down the Calcutta's outfall, has silted up 30 ft. during the last 21 years. No serious notice was taken of this timely warning either by the Government of Bengal or by Calcutta Corporation. In 1912, Mr. Adams Williams, another Irrigation Engineer of repute, declared that the bed of the river had further gone up by 18 ft. in eight years. It was not, however, till 1918 that any attempt was made to revive the Bidyadhari. Remedial measures to prolong the life of the river then came in quick succession, for, in the course of next six years nearly 20 lakhs of rupees were spent in opening out spill areas and dredging the upper reaches of the Bidyadhari and other measures. These attempts not only proved to be futile but appeared to have accelerated the rate of deterioration.

In 1928, the Government of Bengal, on the advice of their experts, finally declared that 'it is impossible to maintain the Bidyadhari and Government had no intention to maintain the same'. In the meantime the Corporation—fully alive to their responsibility in the matter of satisfactory disposal of the city's drainage—prepared several schemes for shifting their outfall to some live river. The choice, however, lay between only two rivers available near Calcutta (i) the Hooghly on the west, and (ii) the Kulti about 17 miles to the east of the existing outfall.

The idea of shifting the outfal lto the Hooghly was, however, abandoned not only for excessive cost of acquisition of land as Hooghly banks are thickly populated, but also for erection of complete sewage purification work which must follow as a necessary adjunct as the intake station of water supply is situated on the same river.

In 1935, it was decided to discharge the sewage and storm water of the city into the river Kulti by two channels—carrying separately the storm water and daily dry weather flow. The question of disposal of sewage in its crude form to the new outfall was considered from various aspects. The objection mainly was that suspended solids in sewage would settle forming deposits—which in the absence of oxygen would undergo putrefaction and make a demand on the dissolved oxygen of the overlaying water. Such putrefying deposits would give off gases and masses of gas-filled deposits would rise to the surface of the river forming scums. Mud banks of sewage solids of objectionable colour and odour would be formed in the river near the outfall and would harm the fish life of the river in general. The carrier channel, being tide-locked twice a day, sewage solids would also deposit in the same and would require periodical silt clearing—which in a 17 mile long channel is not only very expensive but troublesome. Consideration of these facts led the Corporation to adopt pre-settlement prior to discharge into the carrier channel. Expenditure on sewage purification to any further degree beyond sedimentation was not considered necessary at this stage as the effective dilution available at the outfall works and self-purification power of river water were considered sufficient to deal with the clarified sewage without any impairment to the quality of the river water.

Characteristics of Calcutta sewage.

Ordinarily crude Calcutta sewage contains 99·9% of water. The remaining constituents (usually much less than 0·1% by weight of the total product) include objectionable substances, which may be classified as follows:—

1. Floating Solids.
2. Fats and Grease.
3. Suspended Solids.
4. Organic Matters.
5. Bacteria.

The principal advantage in the composition of Calcutta sewage as compared with that of European cities or other towns in India like Nagpur, Titagarh, Jamshedpur and others, is the great difference in the volume of daily water supply which dilutes the wastes reaching the sewer.

In towns mentioned above, the water supply varies from 20 to 30 gallons per capita whereas in Calcutta the water supply is 65 gallons per capita; such an abundant water supply automatically dilutes Calcutta sewage nearly three times than in other towns. In addition to the above there is a further prospect of increasing the supply by 50%.

The chemical analysis of sewage of this city for a complete cycle of twelve months (*vide* Table given below) shows that the sewage is very weak and almost purely domestic in character.

On the standard of albuminoid ammonia and oxygen absorption the sewage of Calcutta is much weaker than that of any of the other cities mentioned above.

In Manchester, Birmingham, Chicago and other cities, sewage is treated by Activated Sludge Process, which is recognised to be the most up-to-date and effective means of purifying sewage. In all these cases it is found that the purification effected is about 85% on the basis of oxygen absorption and 82% on the basis of albuminoid ammonia.

The sewage of Nagpur was treated by Activated Sludge Process. Comparing the crude sewage of Calcutta with the treated sewage of Nagpur it would be apparent that on the standard of albuminoid ammonia and oxygen absorption, the treated sewage of Nagpur is 100% stronger than the crude sewage of Calcutta. The sewage of Nagpur

Analysis of crude sewage of Calcutta and other important cities.

	In parts per 100,000.			
	Suspended solids.	Albuminoid ammonia.	Oxygen absorptions in 4 hours.	
In India.				
1. Calcutta (crude sewage) ..	37·7	0·71	4·9	Average of analysis throughout the year of 1932.
2. Tatanagar do. ..	..	1·20	12·6	
3. Nagpur do. ..	176·5	3·90	42·3	
3(*a*). Nagpur (after purification)	10·0	1·96	11·2	
Outside India.				
Manchester (crude sewage) ..	45	0·85	4·26	
Chicago (packing town crude sewage)	60·5	7·9	26·8	
Mansfield (Ohio)	87·6	3·1	5·1	

is very strong and may be taken as an exceptional case. But ordinarily purification effected in sewage treatment works may be taken as 80% on the standard mentioned above.

Effect of Calcutta sewage on outfall river.

Now the various harmful effects on streams or watercourses due to sewage pollution may be considered briefly. They are classified below from the standpoint of Calcutta's new outfall to Kulti river.

1. Contamination of public water supply.
2. Creation of nuisance affecting public health and comfort.
3. Damage to property with resulting depreciation in values.
4. Effect on fish life.
5. Damage to Harbour Improvements.

(1) The water of river Kulti is saline and as such is never used for any domestic purpose. The question of contamination of water supply therefore does not arise.

(2) As nearly 90% of the settleable solids is removed from the sewage by pre-settlement and as the dilution ratio is high, chances of formation of unseemly black sludge banks are very little.

(3) The line of the drainage canal passes through an area very sparsely populated. This drainage channel has not adversely affected value of the land, but on the other hand, as both better drainage and irrigation facilities have been made possible, there is already a tendency towards appreciation of land values.

(4) Fish life will not be affected, but on the other hand there is every possibility of rapid growth of same owing to the nutrition value of the effluent now discharged into Kulti.

(5) The question of damage to Harbour Improvement also does not arise in this case as there is no such thing on the Kulti river.

These factors were carefully considered by an Expert Committee, set up by the Government of Bengal, who advised the Corporation that for the present pre-settlement of sewage in continuous flow sedimentation tanks was all that was necessary.

Location and description of Sedimentation Tanks.

The site selected for the sedimentation tank is at Bantala (Plan No. 1) near the old outfall and is situated on the east bank of the now defunct Bidyadhari. Here the dry weather flow channels from the city and Manicktala will meet and will be led into the sedimentation tanks through a common carrier channel. The site was originally the bed of the Salt Lake and the river Bidyadhari and as such is water-logged. It is away from habitations. The land here is cheap and the surrounding area being low the problem of final disposal of sludge would be solved most economically. The general layout of the sewage works at Bantala is shown in the Plan No. 2.

To get a good settlement about one and half hour's retention was considered necessary. This detention period was decided upon after carrying out several experiments in quiescent state and it was noticed that more than 85% of settleable solids were deposited by this period and further reduction of settleable solids required such a long period which would hardly justify the extra capital cost for additional tankage capacity required for the purpose.

Two circular tanks of Pruss type similar to that installed at Emscher (Germany), where it has given most satisfactory results, were decided upon on the following considerations:—

(1) There is an absence of eddies and cross currents and ideal conditions are obtained for settlement of even the light suspended matter; thus the final effluent passing over the periphery weir contains a minimum amount of suspended matter.

(2) Prompt and continuous removal of sludge is possible and the mechanism for such removal is almost foolproof.

The inside diameter of each tank is 260′ (Plan No. 1) and average depth 13′ giving the total capacity of nearly 3·75 million gallons for each tank. These tanks, it may be stated, are the largest of their kind so far constructed in the world, the one at Emscher in Germany being 223′ diameter. Each tank has two concentric zones separated by screens called grills to ensure even distribution of flow from the inner zone to outer zone so as to reduce the formation of eddies and cross currents to a minimum. With both tanks in operation the inner zone will give a retention period of an hour to the average dry weather flow of the city. The outer zone another 35′ wide will permit of a further retention period of another half an hour to arrest the finer silts.

There is a revolving bridge spanning from the centre of the tank to its extreme edge which makes a complete revolution in about one and a half hour's time. From this bridge there are a series of suspended scrapers both for inner and outer zones which by the above slow motion of the bridge constantly scrapes the bottom of the tank in such a way that the silt deposited is collected at the centre of the tank. The silt thus accumulated at the centre is lifted by purely hydrostatic pressure into another chamber called the dry chamber (also situated at the centre of the tank but completely isolated from other portion of the tanks). The entire operation of the tank in settling and carrying the silt up to the dry chamber is done purely by gravitational force with the exception of movement of the revolving bridges. The sludge from the dry chamber is then lifted by mechanical power by about 15 ft. and led to large shallow tanks constructed above ground level called lagoons.

The clear effluent properly settled in the tanks is then led by gravitation into the head end of the dry weather flow channel.

DILUTION OF SEWAGE IN DIFFERENT SEASONS.

The average discharge of storm water from the city during rainy seasons, July to October, is roughly 2,400 c.ft. per second, excluding the quantity discharged directly into the Hooghly river and Tolly's Nullah by penstocks. These volumes mingled with normal daily outflow of sewage dilute the same during the monsoon period to such a ratio that it appears almost non-obnoxious. Roughly speaking, the sewage is diluted 8 to 10 times during the monsoon period. The sewage as such is so weak in character that even untreated and unsettled sewage discharged into the Kultigong is not likely to injure any fish life. During average spring ebb-tide discharge of the Kultigong as actually observed in August, 1943, is 20,334 c.ft. per second and against the present maximum sewage discharge of 180 c.ft. per second. This gives a dilution ratio of 113·1 during the monsoon season. During the dry weather, this ratio falls to about 95·1, which under all circumstances is considered to be quite safe and reasonable.

Nutrient value of sewage sludge and sewage effluent.

Sewage contains chemical constituents, like nitrogen and phosphorus, which possess fertilising value. Sewage sludge as fertilizer has been used and is being used in many countries, specially in Germany and America. Apart from its nitrogen and phosphorus content, the 'Humus' in the sludge is known to have beneficial effect on conditioning the soil, a factor totally non-existent in case of artificial manure like sulphate of ammonia.

Besides these, in recent years eminent experts like Rudolf, Heinemann and Ingols have established that sewage sludge contains growth-promoting substances something similar to riboflavin, a growth-promoting vitamin.

Riboflavin is a chemical name of the compound formerly known as Vitamin G and at present as Vitamin B_2. Riboflavin has been found to increase the germination of pollen grains. It is also observed that this substance, in proper concentrations in chicken feed, increases the hatchability of eggs.

Riboflavin is considered essential to the well-being of animal life as well. Deficiency of this vitamin may cause a decrease in the rate of growth and reproduction. This deficiency would also cause disease of the eye, the skin and the nervous system.

In raw sewage, a substance similar to the above vitamin is present in concentrations varying from 20 to 44 micrograms per litre and settling has practically no effect on the riboflavin content of sewage. Effluent from activated sludge plant, however, contains only 4 to 5 micrograms of this substance.

It has also been established that sludge from activated sludge plant contains at least twice as much of this substance as contained in sludge from a Pre-settling Tank.

Fisheries and sewage.

Salt Lakes, which lie to the east and south-east of the city are vast tract of water-logged swamps, covering nearly an area of 30 sq. miles. This low-lying land, originally formed the spill area of the once mighty tidal river Bidyadhari. If nature was left to herself and if human agencies did not interfere with the regimen of the river by premature reclamation of this low-lying land, one could have expected to have found this swamp raised to a table-land fit for agriculture and human habitation by deposition of silt carried by the delta forming river. But unfortunately this was not to be. Attempt at premature reclamation of this land has made the river Bidyadhari and Peali, what we find them today. The bed of the river is higher than the surrounding country with the consequent result that this large area adjacent to the city remains undrained and water-logged and very favourable breeding ground for malaria-mosquitoes. The Government of Bengal, it is understood, is now considering the proposal of reclaiming only a portion of these Salt Lakes at a huge cost of nearly three crores of rupees. If only a fraction of this amount was spent fifty years ago on river training works and if judicious reclamation of land on a planned basis was undertaken, one may venture to say without fear of contradiction that Calcutta would not have found herself in this pitiful condition and the people of Bengal need not have been saddled with this huge expenditure, which might have been profitably used for other nation-building work.

But at the beginning, say 40 years or 50 years ago, prospect was very bright. The swamp was cut up into bits of areas by putting in 'bunds' or embankments. Water from the river, which in certain seasons used to bring up fish spawns from the sea, used to be let in at high tide. At the ebb tide a portion of the water which found its way in this area was used to be let out into the river and by means of simple contrivance made with bamboo-sticks, the fish spawns and small fry were prevented from going out into the river. Each plot of swamp, varying from 200 to 1,000 acres, was used for rearing salt water fishes like Bhetki (*Lates calcarifer*), Parsia (*Mugil parsia*), Bhangur (*Mugil tade*) and Prawns and were known as 'Nona Bheris'. Average depth of water in these fisheries used to be from 3′ 6″ to 4′ 0″. This used to be a very profitable business as huge income could be made at little or no cost. But nature cannot be mocked for any great length of time. This procedure of restricted ingress and egress of water had its effect on the river. The river had silted up rapidly as the silt brought up by the high tide could not spread over the spill area, but was deposited in the river bed itself. Gradually difficulty was felt in draining the fisheries and letting in water, which carried the fish spawns. Owing to the reduction in cross sectional area of the river, less and less water began to flow up. At the same time the city expanded rapidly (*vide* Plan No. 3) and larger volume of sewage had to be discharged into the river. Thus the dilution ratio was reduced and water became more and more polluted till a time arrived when it became difficult for fish life to exist, and the once powerful river so dwindled in section that it became a high level carrier of Calcutta's septic sewage and the once very profitable 'Nona Bheris' became large plots of non-productive fallow and undrainable swamp.

In 1930, a Zamindar in this locality finding in his land vast area of non-revenue yielding land, attempted to culture Carp fishes by letting in sewage in small doses into the fisheries. The result obtained was very encouraging and within a short period practically the whole of this area was converted into fisheries for culturing freshwater fishes. There were, however, difficulties in draining the fisheries, until the Storm Water Channel was completed in 1940, as even the bed level of the only drainage channel, Bidyadhari, was higher than the adjoining ground level. It often happened that during the monsoon the banks of the fisheries either overflowed or breached causing heavy financial loss to the owners of the fisheries.

Then the Storm Water Channel from Bantala to Kulti was constructed and completed by 1940 which gave immense relief to the adjoining areas. Draining became feasible and sewage was fed into the fisheries as and when required. Then the Dry Weather Flow Channel was constructed on the northern side of the Storm Water Channel and the fishery owners on the north got the full benefit of feeding their fisheries with sewage water. During the dry weather there is a great demand from the fishery owners for the sewage and it has been clearly established that but for the sewage of Calcutta, Carp culture in this area would not have been either possible or profitable.

In Munich, sewage and effluent from sedimentation plants are let into shallow ponds and tanks where Carp is cultured.

Considering the demand on Calcutta sewage for the purpose of fish culture, a considerable revenue could be earned by the Corporation if sewage or effluent from the sedimentation tanks was distributed amongst the fisheries through controlled channels.

Irrigating fisheries by Calcutta sewage.

New drainage channels of the Calcutta Corporation to the Kulti river provide almost unique facility to the fishery owners, both as regards feeding and draining. One of the channels (the Dry Weather Channel) carrying pre-settled effluent from the Sedimentation Tanks usually runs at a high level and its level can be adjusted by means of a Regulator to ensure almost continuous feeding of the fisheries to the north from the D.W.F. Channel. On the other hand, the Storm Water Channel, running parallel to D.W.F. Channel and in very close proximity to it, is a low level canal, whose level (even in monsoon) can be kept 3 to 4 ft. lower than the adjoining fisheries. Simultaneous feeding and drainage facilities (a rare combination) can thus be given to the fisheries to the north by means of suitably constructed syphons and other under-structures below the high level D.W.F. Channel. The fisheries to the south of the Storm Water Channel are, however, not so favourably situated as those on the north. For the present, they are getting the facility of efficient drainage only from the Corporation. If, however, the fishery owners of the south are keen, and, there is no reason why they should not be, suitable syphon below the Storm Water Channel can be constructed to divert pre-settled sewage from north to the south, as sufficient head is always available to feed southern fisheries from the D.W.F. Channel allowing necessary head loss for syphon.

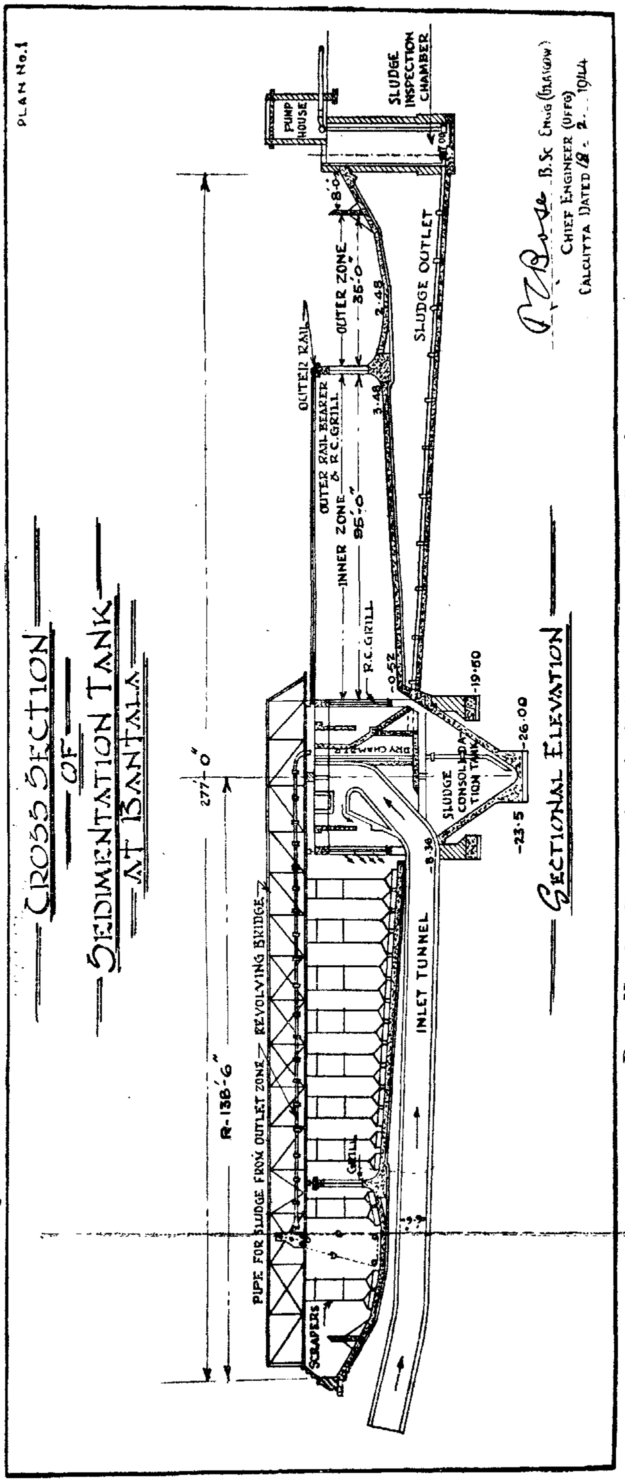
There is a third additional advantage to the fishery owners to the north. The Government Salt Water Canal, viz. the Bhangore Khal, runs along the northern boundary of these fisheries and as such they can, with Government permission, take salt water to improve the rearing of the fishes. This is, however, not always possible by gravitation as the level of the Bhangore Khal is not allowed to fluctuate much in the interest of navigation, still there is scope for considerable improvement to induce more saline water into the fisheries from Bhangore Khal.

Conclusion.

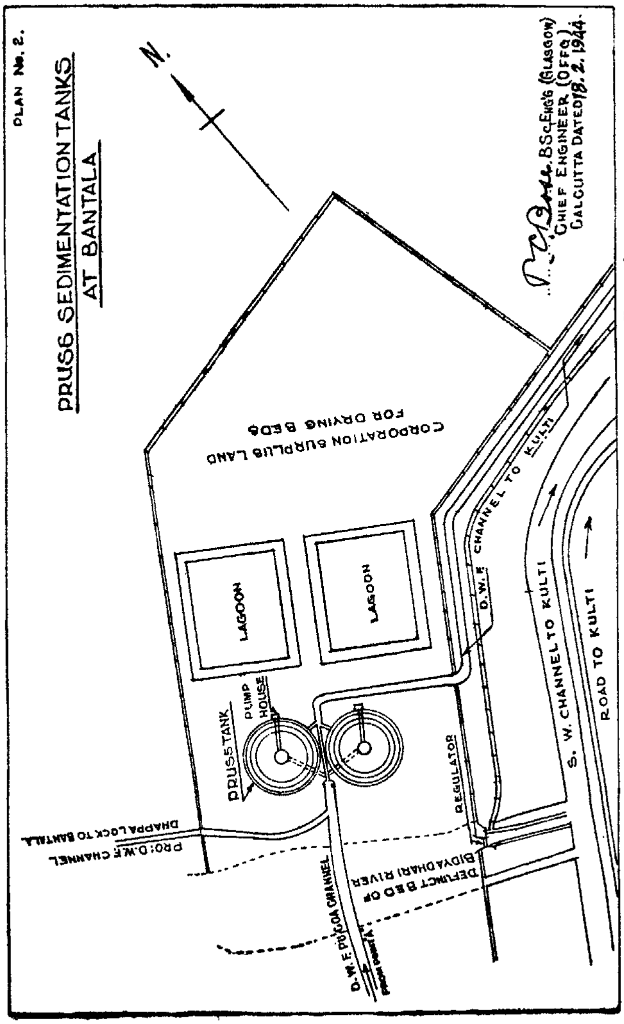
It will be clear from what has been stated above that the topographical situation of the Government and Corporation canals near Calcutta, so far as fish culture on a scientific basis is concerned, is an ideal one. A proper co-ordination between the Government and Corporation in this respect is sure to improve the present unsatisfactory method of primitive fish culture and will go a great length in solving acute fish shortage of the city. By introduction of proper and suitable regulating works both in canalised Bhangore Khal and in Corporation canals feeding and drainage of fisheries can be continuously performed with pre-settled sewage. To supplement the above it is also necessary to excavate a series of properly designed arterial feeding and drainage channels in the fishery itself as indicated in Plan No. 4. I am confident that with the introduction of above arrangements the yield of fish crop per acre will substantially improve and being situated so near an all-swallowing market like the city of Calcutta, they will enjoy a good and flourishing market. In return of the above, the fishery owners will, I hope, have no hesitation to pay reasonable cess to Government and Corporation which, therefore, will be a permanent source of income to both the bodies.

Summary.

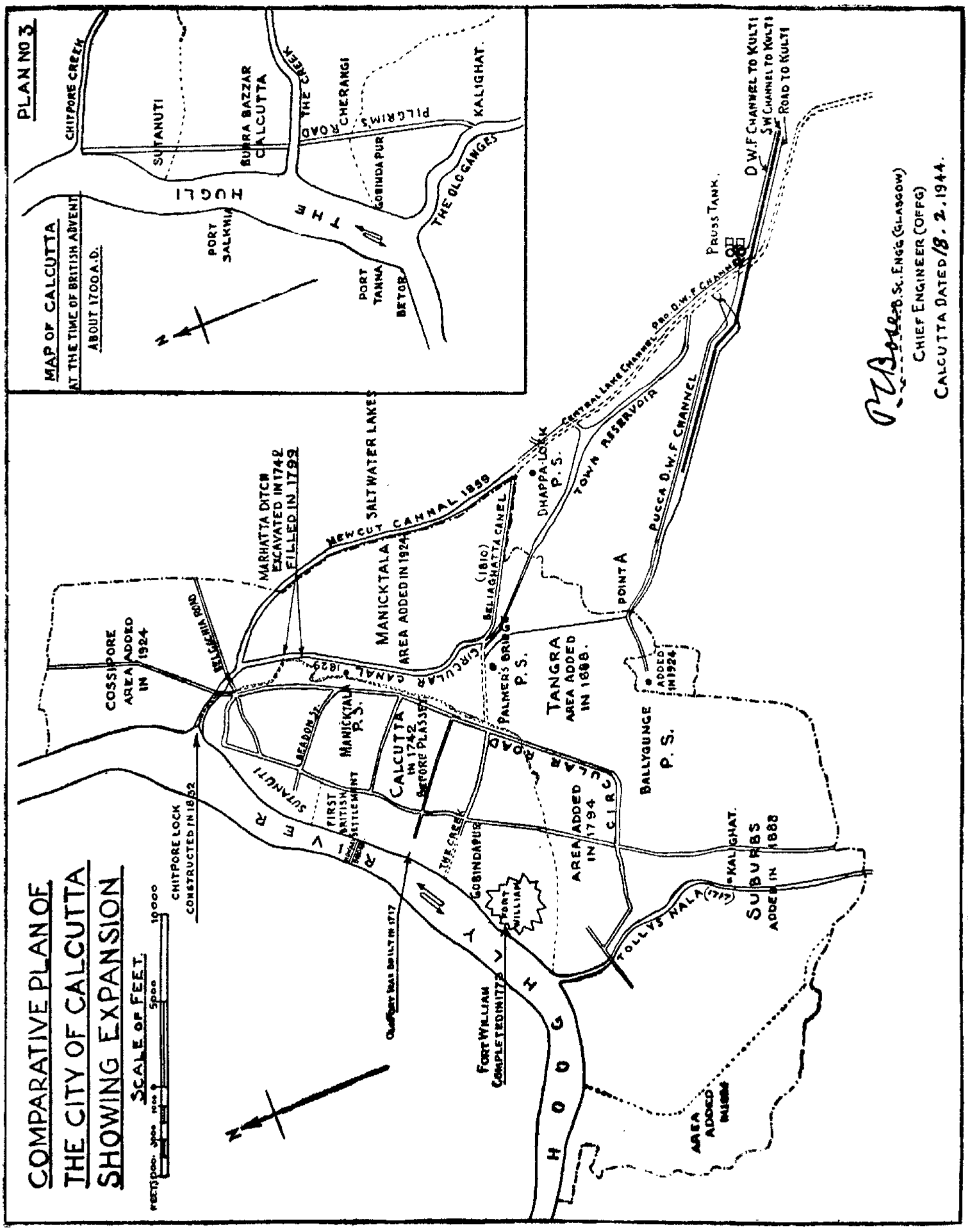
A brief history of the Calcutta drainage and outfall is given. The main characteristics of the Calcutta sewage are described and compared with those of the sewage of certain Indian and foreign cities. The effect of the Calcutta sewage on the outfall river is discussed. The location and description of the sedimentation tanks are given. The dilution of sewage in different seasons and the nutrient value of sewage sludge and sewage effluent are described. Attention is invited to the utilisation of sewage for the culture of saltwater fishes when the Bidyadhari river was alive and its present use for irrigating carp fisheries. Suggestions are made for the proper utilisation of the existing facilities for the culture of fish in the areas lying alongside the sewage channel.



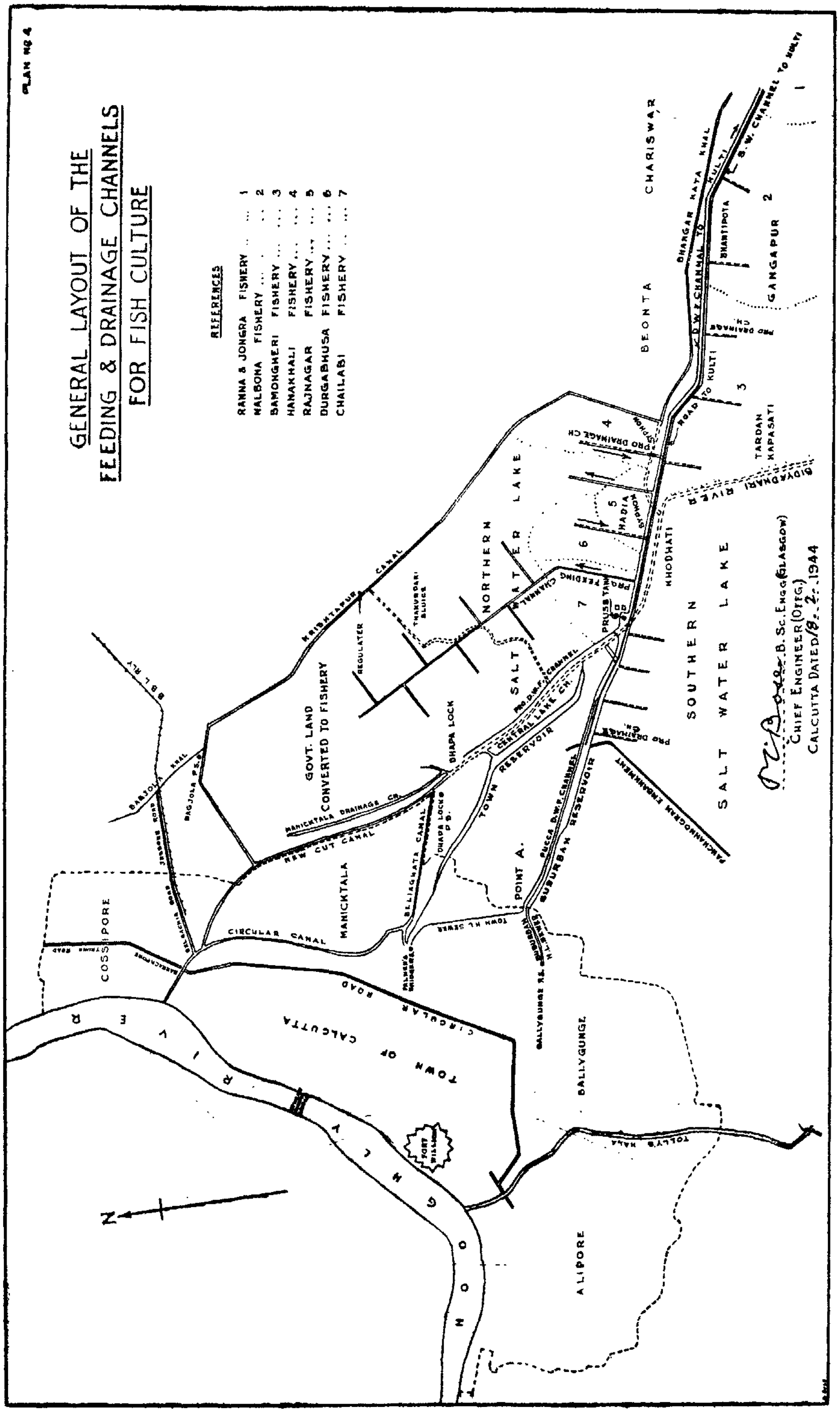
PLAN No. 1. Cross Section of a Sedimentation Tank at Bantala.



PLAN No. 2. Pruss Sedimentation Tanks at Bantala.



PLAN No. 3. Comparative Plan of the city of Calcutta showing expansion.



PLAN No. 4. General Layout of the feeding and drainage channels for fish culture.