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Salinity Intrusion in Local Rivers in Relation to Water Supply Intakes

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Abstract : *Salinity Intrusion into water intake areas of rivers during dry spells of the year has become an ever increasing problem. In this paper an attempt has been made to create public awareness about the situation considering some wet zone rivers. The present situation and alternative methods adopted to avoid the problems has been discussed with some examples and case studies. Construction of salinity barriers appears to be an appropriate solution to the problem.*

1 Introduction

All major Water Supply Schemes in Sri Lanka are sourced by surface water sources such as rivers and tanks. To serve major coastal towns, water intakes have been located within a 5-30 km range away from respective river mouths. Let us consider such intakes located in the following Wet Zone rivers, namely Mahaoya, Kelani, Kalu,Gin, Nilwala and Walawe to serve some of the major towns.

It is necessary to extract water quantities ranging from 0.1 m^3/sec (Walawe) to 6 m^3/sec (Kelani) from these rivers to maintain water supply for the respective areas at present.

The details are given in Table 1.

It has been increasingly difficult to extract these quantities during dry spells of the year due to the salinity intrusion experienced at the intake areas.

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2 Background of the Problem

In the old days most of these intakes were located not very far away from river mouths and it had been possible to extract the required quantities of water throughout the year without any salinity problem.

However now it has been observed that the sea water/fresh water interface is gradually approaching the water intakes during the dry spells of the year, specially during the months of February, March and August as shown in Figure 1.

This is due to the lowering of the river bed level as a result of ongoing sand mining, gradual reduction of river flows, variation in Mean Sea Level (MSL) connected with variation in tide, large scale extractions upstream of National Water Supply & Drainage Board (NWSDB) intakes and increase in sea level due to global warming.

3 Alternative Solutions Adopted

3.1 Intermittent intake of water

To avoid salinity by monitoring the salinity level at the intake, the pumps are operated and stopped during high salinity.

Table 1: *Location of Intakes, Present Extraction & Area Served*

River	Intake Location	Present Extraction m^3/sec	Area Served
Mahaoya	Bambukuliya	0.25	Negombo, Katunayake
Kelani	Ambatale	6.00	Greater Colombo
Kalu	Kethhena	0.4	Wadduwa, Kalutara, Aluthgama
Gin	Wakwella, Amugoda, Baddegama	0.6	Balapitiya, Ambalangoda, Hikkaduwa, Galle
Nilwala	Nadugala, Kadduwa,bal ukawila	0.5	Mirissa,Kam-burugamuwa, Matara, Dikwella
Walawe	Ambalantota, Bolana	0.1	Hungama, Ambalantota, Hambantota

According to World Health Organization (WHO) standards

Max. allowable Cl^- =250 mg/l

According to Sri Lanka Standard (SLS)

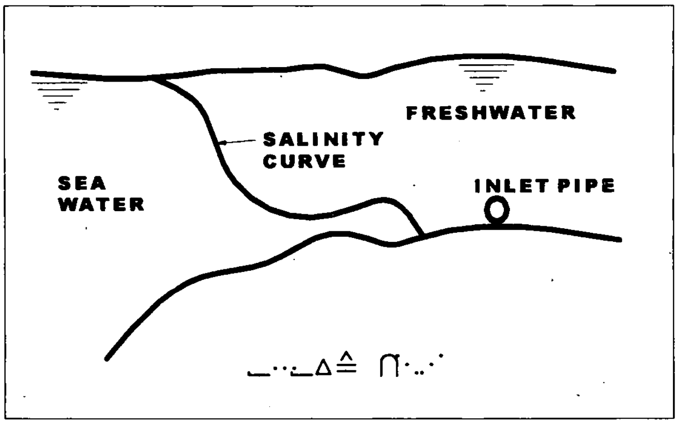
Max. desirable Cl^- =200 mg/l

Max. allowable Cl^- =1200 mg/l

Cl^- - Chloride Iron Concentration in mg/l

Beyond this limit the salinity of water could be felt.

However pumping is done upto Cl^- concentration of about 1000 mg/l level is reached (conductivity is about 3000 μs/cm at this level) in order to meet the water demand.



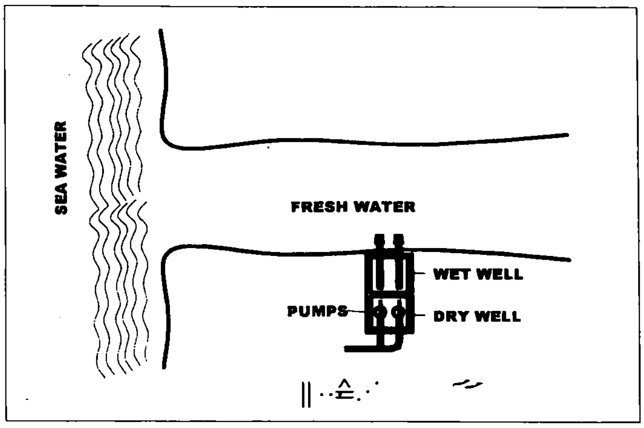


Figure 1: *Typical layout of a water Intake, River & Sea*

3.2 Floating Bucket Arrangement

Extracting water just below the water surface by floating bucket arrangement as shown in the Figure 2.

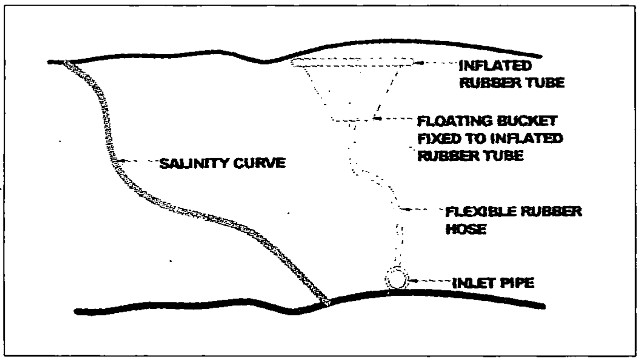


Figure 2: *Floating bucket arrangement*

3.3 *Temporary Barriers*

Construction of temporary barriers across rivers using sand bags as shown in Figure 3

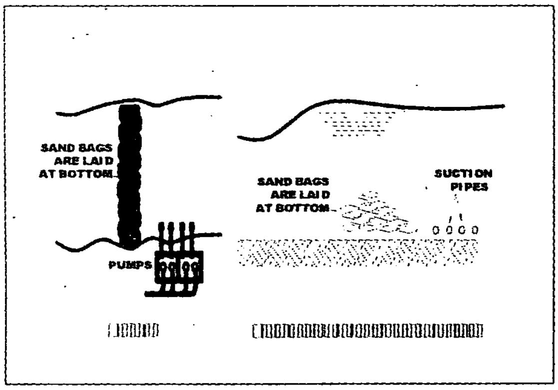


Figure 3: *Details of Temporary barriers*

3.4 Shifting Intakes

By locating a new intake upstream of the river, beyond the reach of salinity wedge.

Limitation of this option are;

- Higher Capital Cost
- Higher O & M Cost
- Lesser flow in the river.

Figure 4 shows the water intakes on rivers Gin, Nilwala and Walawe.

On Gin Ganga the first Intake was constructed at Wakwella about 7 km from the sea in 1976 for water supply to Galle. Due to salinity intrusion, the second intake was constructed at Amugoda a further 4 km upstream under the augmentation project in 1993.

On Nilwala the first intake was constructed at Nadugala, 8 km from the sea in 1963 for water supply to Matara. Due to salinity intrusion, the second intake was constructed at Kadduwa another 8 km upstream to avoid salinity in 1984.

As the salinity wedge reached Kadduwa also a third intake was constructed at Balukawila another 06 km upstream in 1997

On Walawe Ganga the first intake was constructed at Ambalantota in 1964 for water supply to Hambantota, 5 km from the sea. Due to salinity intrusion, the second intake was constructed in 1983 at Bolana a further 6.0 km upstream.

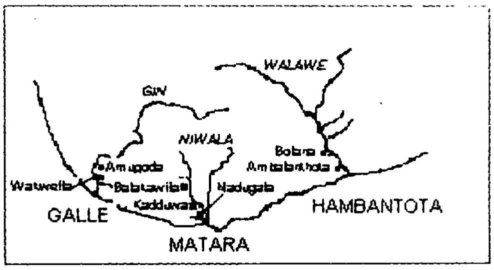


Figure 4: *Intake on Gin,Nilwala & Walawe*

Figure 5 shows the major water intakes on Kalu, Kalani and Mahaoya.

The Intake for Kalutara Integrated Water Supply Scheme (WSS) was constructed at Kethhena 15 km from the sea in 1986. Now there are signs of salinity reaching the intake. Therefore a new intake to supply water to Greater Colombo area is now under construction at Kandana, Horana, 15 km upstream of Kethhena. However when the extraction starts at the new intake it is expected that the salinitv will reach Kethhena Intake.

Therefore studies have already begun to construct a salinity barrier downstream of Kethhena.

The main water intake for Colombo water supply is located on Kelani at Ambatale. With the gradual increasing of quantity of water extracted, salinity intrusion is taking place during dry spells, of the year. With a temporary sand bag barrier as shown in Figure 3 NWSDB is managing it with great difficulty.

Already NWSDB has embarked on a project to construct a salinity barrier at Ambatale as a permanent solution.

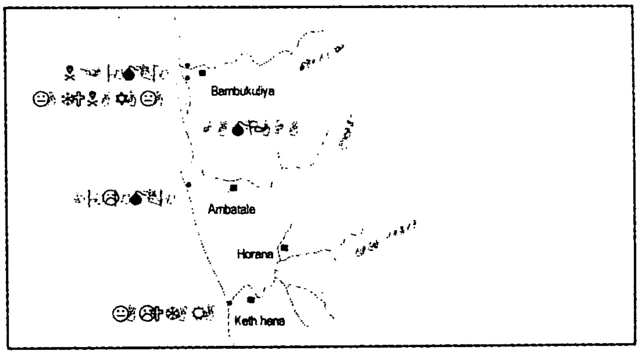


Figure 5 : *Intakes on Kalu,Kalani & Mahaoya*

3.5 Construction of Permanent Salinity Barriers

3.5.1 Negombo WSS

The Intake is located at Babukuliya on Mahaoya, 7 km from the river mouth. In 1986 a submerged weir was constructed across the river as shown in Figure 6 to create a ponding effect to facilitate the extraction of more water into the intake and to avoid salinity intrusions. The length of the weir is about 80 meters.

After this construction it was possible to increase the extraction from 130 l/s to 265 l/s without salinity intrusion.

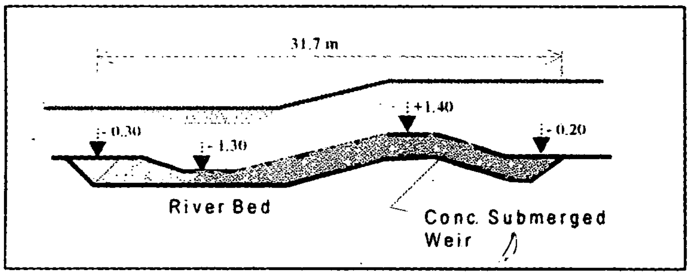


Figure 6: *Submerged Weir*

3.5 2 Hambantota –Ambalantota WSS

As there were some signs of salinity reaching Bolana intake a small concrete barrier was constructed just downstream of Bolana intake to prevent it and also to prevent silt and sand getting into the pump house as shown in Figure 7, in 1993.

After this construction the silting of intake was stop and it was possible to increase the intake of water from 70 l/s to 120 l/s without any salinity intrusion.

3.6 Proposed Salinity Barriers

Further salinity barriers have been proposed after detailed studies. as shown in the Figure 8 at

① Kelani-Ambatale [1]
② Kalu-Kethhena [2]
③ Gin-Wakwella (Construction already started) [3]
④ Nilwala --Bandaththara [4]

3.7 Adverse effects of Salinity Barriers

The adverse effects of salinity barriers are

1. Increase upstream effects during flooding.
2. Upstream sedimentation
3. Downstream erosion.
4. Promotion of sand bar formation at river mouth
5. Disruption of navigations and fish movement during closure.

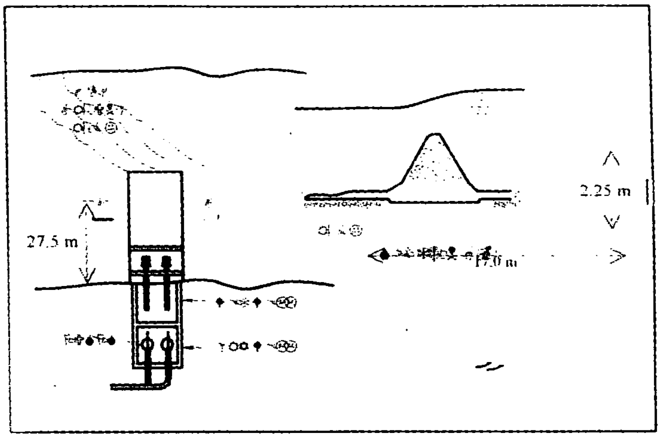


Figure 7: *Salinity Barrier at Bolana*

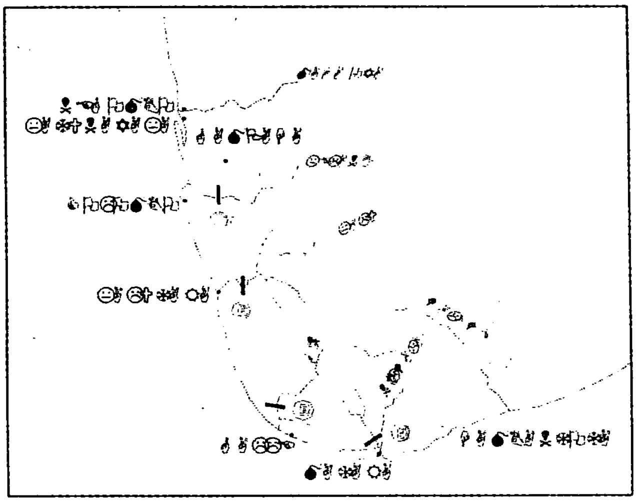


Figure 8: *Location of Proposed Salinity Barriers*

These effects could be minimized by selecting the proper location and type of the structure after a proper study.

4 Case Studies

4.1 Galle Water Supply Scheme:

A case study was done to see the cost implications of shifting Wakwella Intake further upstream to Amugoda to extract another 1 m^3/sec. against the cost of constructing a salinity barrier at Wakwella and to extract the same additional quantity at Wakwella.

From the study it was noted that the cost of constructing a salinity barrier at Wakwella will be about Rs. 250 million [3] whereas the capital and O&M cost of extracting 0.4 m^3/sec for 25 years operation, if the intake is shifted to Amugoda, will be about Rs.360 million. This include the cost of construction of intake structure, pump house, supplying & laying of approximately 4 km long 600 mm diameter Ductile Iron pipe line and the operation and maintenance cost for 25 years period.

4.2 Colombo WSS

According to the studies carried out, in the case of Kelani River the Ambatale intake has to be shifted further upstream by 23 km to Pugoda to avoid salinity and the capital cost of proposed 3 numbers 1 metre diameter Ductile Iron pipe lines alone will be about Rs. 1600 million. [5]. To this amount the cost of land acquisition, construction of new intake, supply & installation of pumps and operational costs are to be added.

Estimated cost of a salinity barrier at Ambatale will be about Rs. 910 million according to the on going project of which the final designs are in progress.

From these studies it appears that the construction of salinity barriers is cheaper than the shifting of intakes upstream to suitable locations which are likely to be rendered unsuitable at a later date.

5 Salinity Barriers in other Countries

Given below is a list of salinity barriers in operation in other countries.

Yodo –Oshaki, Japan
Kino - Wakagama, Japan
Nagara River –Japan
Yoshino (very old-Permanent)- Japan
Tama- Tokyo, Japan
Babol Road River- Iran
Thames River – UK
Senegal River – Senegal
Marseille –France
Ramspol- Netherlands
Rainbow Dam – USA
Angat After Bay Regulator Dam-Philippines
Gubeng Dam –Indonesia
Huay San Pad –Thailand
Kjelda – Norway
Tempe Town Lake –USA
Las Virgenes –Mexico
Brantaas River Menturas –Indonesia
Tena Delta –Kenya
Sheung Shui –Hong Kong

5 Observations and Conclusions

The Ideal solution to the problem would be the construction of large reservoirs at suitable upstream locations of rivers to store the floodwater of these rivers and gravitate/release water to the service areas after proper treatment. Due to the very high investments and the lands required those projects are not financially feasible if only water supply is considered. It may be feasible for multipurpose reservoir projects.

Therefore it is necessary to construct salinity barriers as a solution to this problem, after proper studies to select the correct location and the type of structure to minimize the adverse effects, which will be a cheaper solution.

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