Ashoka Trust for Research in Ecology and the Environment

Report on estimation of inflows into Bellandur Lake

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1. Introduction

Bellandur Lake is located n the south-eastern portion of Bangalore metropolitan region with spatial extent of 370 hectares and a catchment area of 158.5 sq.km. (Figure 1) comprising the Koramangala and Challagatta valleys.

These lakes were originally built to meet the domestic and irrigation demands in the region Their current storage capacity is estimated to be 5.5 M c m. Today, because of unplanned urbanization, the storm water inlets feeding the lake, mostly carry raw sewage. In addition, of course, during the monsoon, the lake receives storm runoff.

The objective of this study is to estimate the sewage inflows into Bellandur lake.

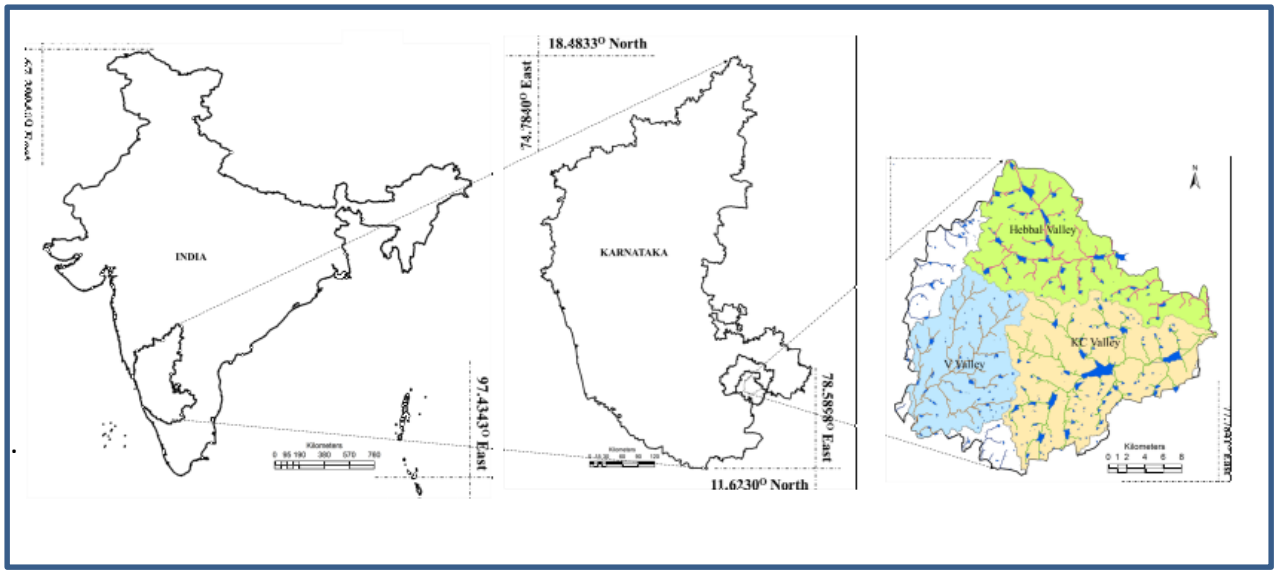


Figure 1: Location of Bellandur Lake
(Figure Source: Bellandur Lake Committee Report)

At present there are three major inlets and two minor inlets through which sewage enters Bellandur Lake.

Figure 2: Map of major inlets into Bellandur Lake

Description of the inlets:
Koramangala Storm Water Drain: This swd is a wide channel (23m close to lake entry where stage was measured). It passes through Ejipura and Koramangala carrying raw sewage from the different wards present in these areas. The channel carries a lot of floating debris and solid waste. There is high sedimentation due to the organic matter.

Agara Storm Water Drain: The Agara drain has connectivity upstream from the Agara lake which was currently dry and being rejuvenated/de-silted . The drain crosses Sarjapur road via a culvert and makes a few turns before entering Bellandur. The section which was monitored had high flow velocities as the channel was constrained. Upstream of the monitoring point, 30 MLD of untreated wastewater is lifted by the BWSSB Agara pump house.

HAL Storm Water Drain: This is a relatively shallow and moderately narrow stream that joins Bellandur lake after crossing Murugesh Palya and HAL airport after which it joins another minor drain and enters the lake.

Iblur Drain : The open channel has been blocked off with soil, next to this lies a relatively small circular conduit carrying wastewater from the Iblur village and surrounding layouts.

Kempapura Drain: This is an open rectangular vegetated channel with shallow flows from Kempapura side

2. Methodology

First the major entry points of sewage entry into Bellandur Lake were mapped and geo-tagged. The sewage flow in each of the storm water inlets entering was measured on a dry day (to ensure no storm water was present).
The drains were profiled and velocity measurements were taken at 0.5 m intervals. Velocity was measured using a HACH velocity flow meter at a depth of 0.4 times the water stage. Stage was measured using an Odyssey Capacitance Sensor. Stage was recorded continuously for about a day at 10 minute logging intervals. The capacitance instrument was placed in a perforated pipe and mounted on a tripod in the stream. The sensors were calibrated prior to installation at each location.

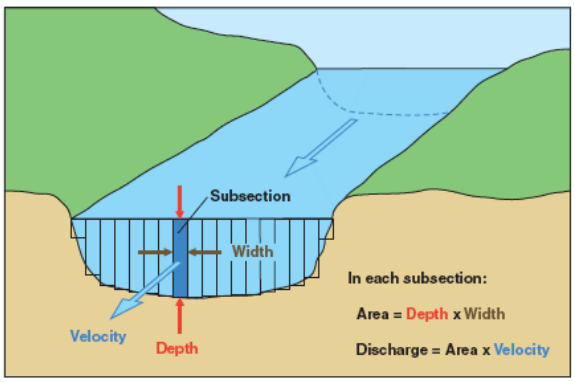
Photo : HACH velocity meter

Photo : Odyssey Capacitance Sensor

Discharge was obtained using the standard method prescribed by USGS.
In this method, the stream channel cross section was divided into numerous vertical subsections (Figure 5). In each subsection, the area is obtained by measuring the width and depth of the subsection, and the water velocity is measured. The discharge in each subsection is computed by multiplying the subsection area by the measured velocity. The total discharge is then computed by summing the discharge of each subsection. By measuring the stage through the data, the total daily discharge is computed.

For the Kempapura and Iblur drains, the flow was found to be too low to use a capacitance sensor or a flow meter. In these drains, the stage was estimated and the surface velocity was obtained through the float method. A correction factor of 0.65 was applied to convert surface velocity to average velocity.

Finally, there was one small pipe from which sewage was found to be entering the lake. Flow from this pipe was estimated using the partial pipe flow formula.

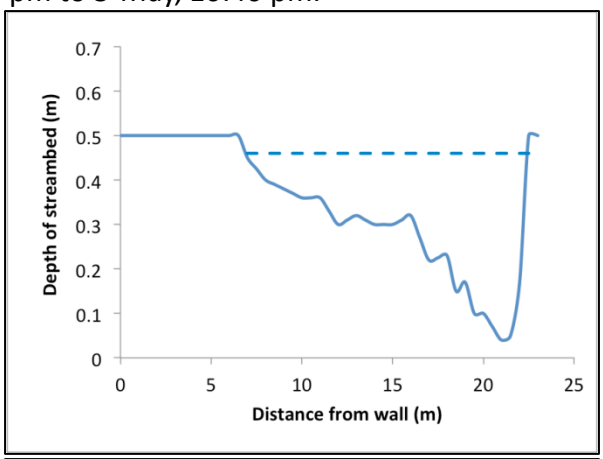


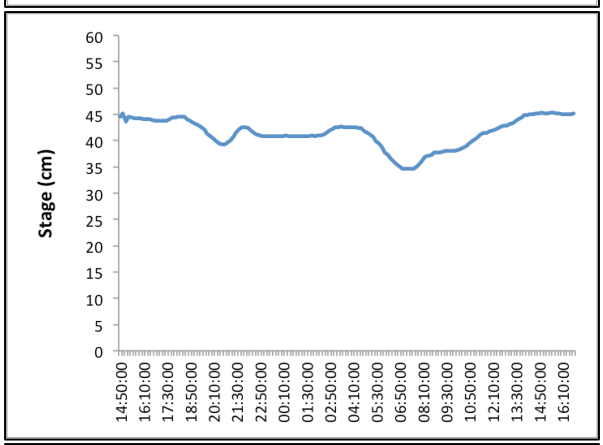
Current-meter discharge measurements are made by determining the discharge in each subsection of a channel cross section and summing the subsection discharges to obtain a total discharge.

Figure 4: Streamflow measurement

3A. Flow Estimate – Koramangala SWD

The measurements were done at 12.92931° N 77.64186° E. This point was accessed from turning off from the Intermediate ring road towards Jakkasandra extension. The stream was approximately 23 m wide and water depth averaged about 25 cm. The continuous monitoring of stage occurred from 4-May, 2:50 pm to 5-May, 16:40 pm.





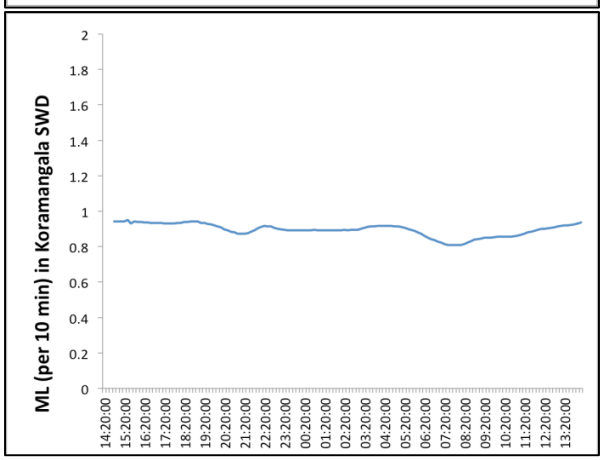


Figure 6: A). Stream Profile B) 24-hour stage and C) Discharge.

Field work at Koramangala Drain on 5 and 6 May 2017

Figure 5: A) 24h Stage monitoring B) Profile measurement C) Velocity measurement

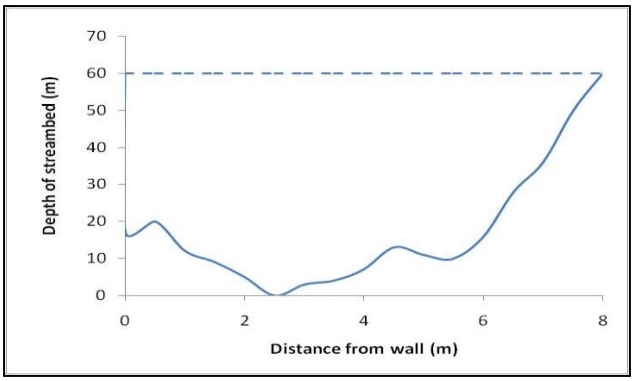
The stage, installed at 17.5m in the profile, did not vary much through the day (barely a 5 cm change through the day) although there was a slight dip in the night and late afternoon.

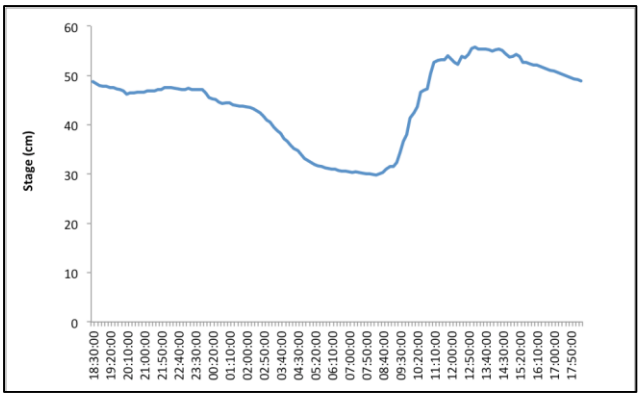
The stream was found to have a continuous sewage flow of approximately 83 **MLD.**

3B. Flow Estimate – Agara SWD

The measurements were done at 12.92634° N and 77.64147° E. This point was accessed from Sarjapur main road side. The stream was approximately 8 m wide and water depth averaged about 45 cm during stream profiling.

The continuous monitoring of stage occurred from 5-May, 6:30 pm to 6-May, 4:10 pm.





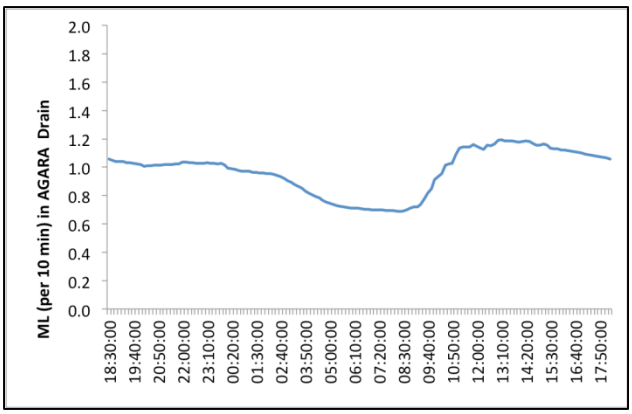


Figure x: A). Stream Profile B) 24-hour stage and C) Discharge.

Field work at Agara Drain on 5 and 6 May 2017

Figure y: A) 24h Stage monitoring B) Profile measurement C) Velocity measurement

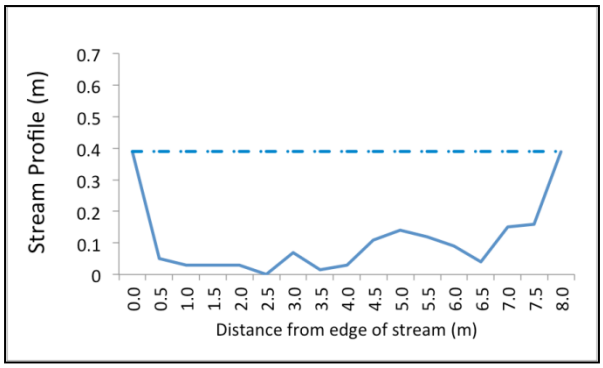
The stage, installed at x=6 m in the profile, dropped significantly by 10-15 cm during the hours of the night, the sizeable drop can be attributed to narrow channel width. The average stage was found to be 44 cm.

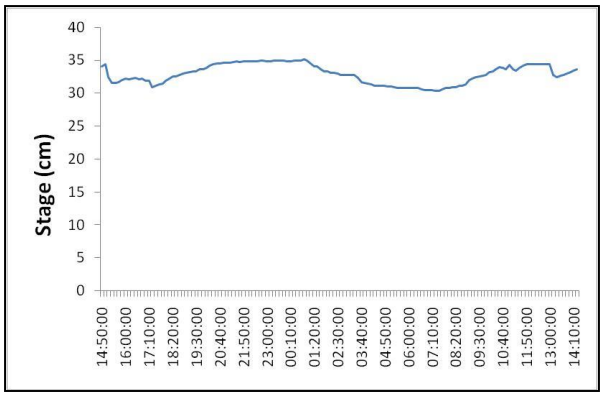
The stream was found to have a continuous sewage flow of approximately 6 million litres per hour or **140 million liters per day.**

3C. Flow Estimate – HAL (Challagatta) SWD

The measurements were done at 12.94563° N and 77.65738° E. This point was accessed from turning left before Chelaghatta STP and going through Belur Nagsandra village. The stream was approximately 8 m wide and water depth averaged about 11 cm.

The continuous monitoring of stage occurred from 5-May, 2:50 pm to 6-May, 2:10 pm.





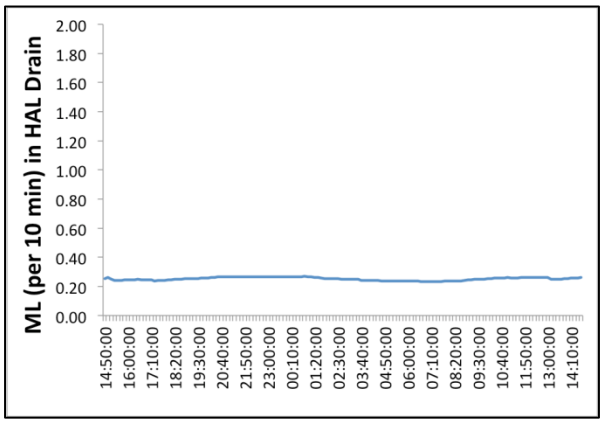


Figure x: A). Stream Profile B) 24-hour stage and C) Discharge.

Field work at HAL Drain on 5 and 6 May 2017

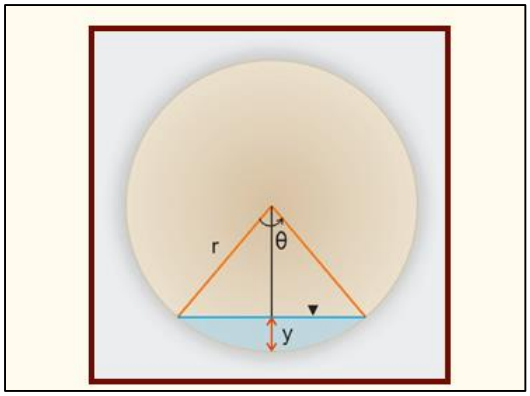
Figure y: A) 24h Stage monitoring B) Profile measurement C) Velocity measurement

The stage, installed at x=4.25m, did not vary much through the day (barely a 5 cm change through the day) although there was a slight dip in the night and late afternoon.

The stream was found to have a continuous sewage flow of approximately 1.5 ML per hour **or 36 MLD.**

3D. Flow Estimate – Iblur

Iblur drain had two inlets: the first was a pipe bringing sewage from a nearby set of apartment complexes. The second was a SWD that was heavily silted and vegetated. In both cases, the cross sectional area of a circular drain, partially filled with water was estimated.



Formulas

$\theta = 2\cos^{-1}[1 - 2(y/D)]$

$A = (D^2/8)(\theta - \sin\theta)$

$P = r\theta$

$R = A/P$

$Q = (k/n)\,AR^{2/3}S^{1/2}$

$V = Q/A$

Type	Pipe flow (partial)
Velocity method	Float
Diameter	0.3 m
Stage	0.1 m
Variation	0.01 m

Discharge in a partially full circular culvert

Pipe diameter	Flow depth	Bottom slope
m	*m*	*m/m*
0.30	0.10	0.0001

Total daily discharge volume	236.71
Total daily discharge volume	0.24

Daily discharge volume 236 m^3

0.24 mld

Type	Open Channel flow
Channel diameter	1 m
Stage	0.22 m
Water Area	0.152198
Velocity Reading 1	0.66 m/s
Velocity Reading 1	0.63 m/s
Flow Estimate 1	5.6MLD
Flow Estimate 2	5.4MLD

Daily discharge volume 5396 m^3

5.4 MLD

3E. Flow Estimate – Kempapura

The flow at Kempapura was estimated using the float method, because the stage was very low. The stream was also not accessible as it had steep sides.

A correction factor was applied to convert surficial flow velocity to average velocity.

Kempapura Drain **May 6 2017** **3:00 pm**
Latitude **Longutude**
Persons Present: Veena, Chandan, Sayan

	Time (s)	Distance (m)	v (m/s)
			0.8361204
Times (5 m)	5.98	5	01
			0.9416195
	5.31	5	86
	5	5	1
Stage	0.03 m		
Section width	2 m		(Rectangular drain)
Cross sectional area	0.06 sq m		
Flow rate 1	0.05017 m3/s		
Flow rate 2	0.05650 m3/s		
Flow rate 3	0.06000 m3/s		
Correction Factor	0.65		
No of seconds/day	86400		

Flow rate 1	2817	m3/day	2.8 MLD
Flow rate 2	3173	m3/day	3.2 MLD
Flow rate 3	3370	m3/day	3.4 MLD

The flow at Kempapura drain was estimated to be 3.2 MLD.

Total untreated sewage flow estimated from all sources

	Estimated (MLD)
Koramangala SWD	83
Agara	140
HAL	36
Iblur	5.6
Kempapura	3.4
	268