# Nitrogen and Carbon Flows through Bellandur Lake

## Bellandur lake as a natural wetland

## treating wastewater

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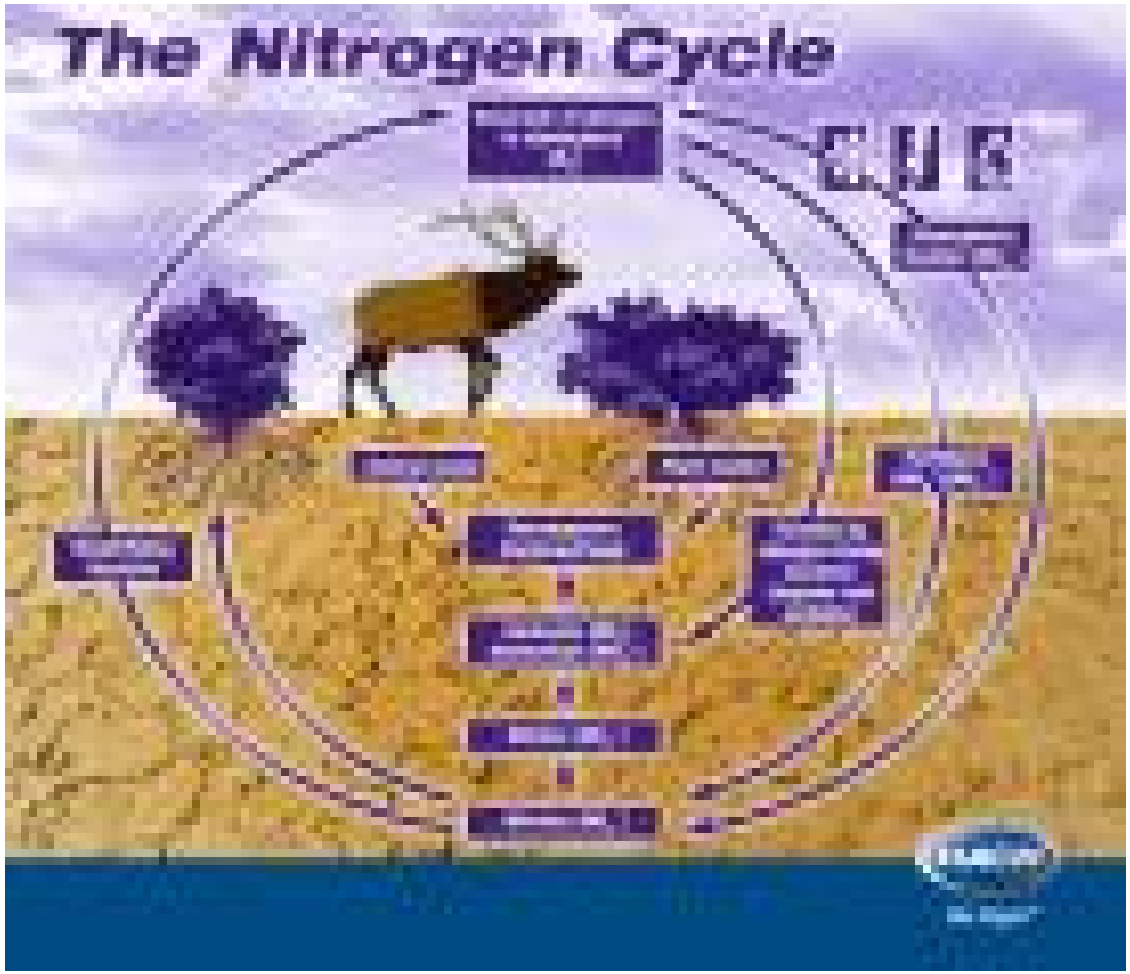
Outline

- The importance of nitrogen – the Harte example
- Conventional N-cycling examples
- The Urban-peri urban distortion
- Our metros and dependence on water bodies to purify
- The case of Bangalore and Bellandur lake
- The current situation
- Conclusions

# Metros, sewage and wetlands

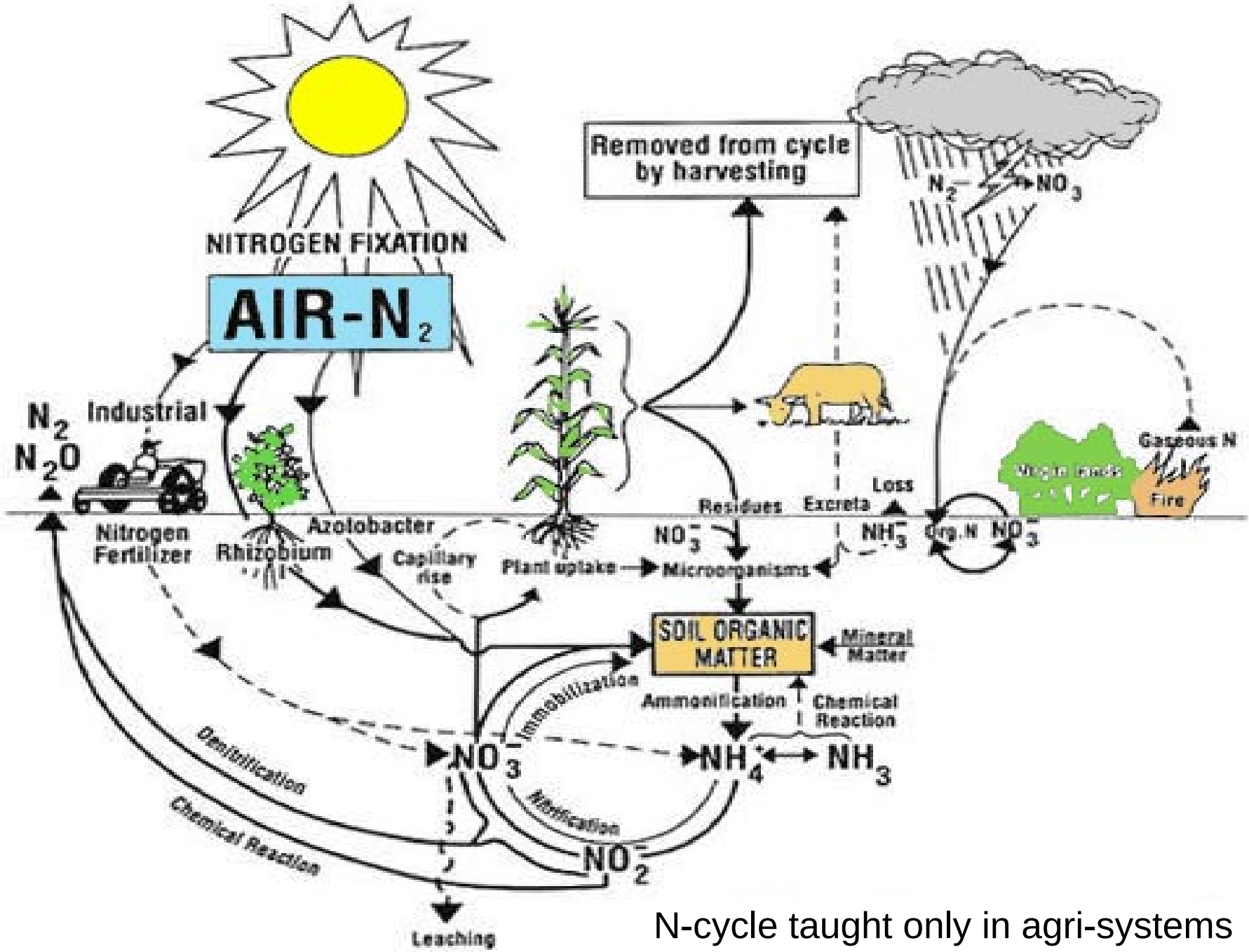
- Wetland systems treating sewage in natural modes
- Kolkata – tidal /salt lakes (c.1850)
- Chennai – two rivers and sea
- Delhi – rivers
- Bangalore – man made lakes (c.200)

Importance of understanding capacities and thresholds for efficiency, aesthetics and safety




Simple picturization of N-cycle in high school science text books

Generally man’s interventions not accounted – considered as small.




N-cycle taught only in agri-systems

$$N_{dep} + N_{fix} = N_i + N_u + N_{ad} + N_{fire} + N_{eros} + N_{vol} + N_{le}$$

| | |
|---|---|
| dep | deposition, |
| fix | -microbial fixation, |
| i | -immobilization, |
| u | -uptake, |
| eros | -erosion, |
| vol | -volatilization |
| le | -leaching |

It is now becoming important to examine how efficiently we are managing our C and N budgets in urban and peri-urban areas. Are these methods sustainable?

# The problem of Bangalore

Lakes receiving sewage at high BOD, nutrient concentration, no primary or secondary treatment

Only some C and N lost during open channel flow

Lakes carrying out primary and secondary treatment incl. nutrient removal

Treatment rarely satisfactory

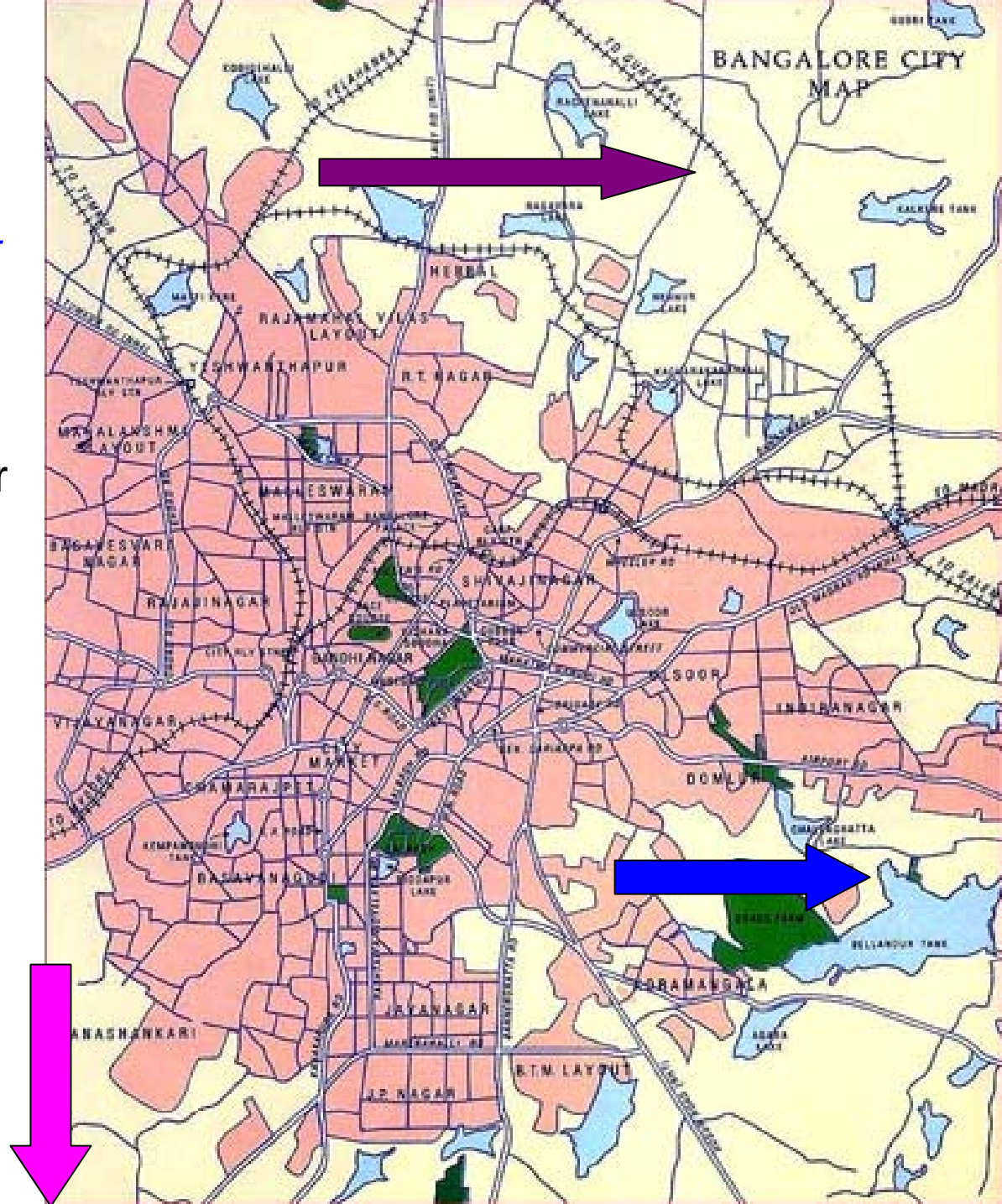
Three main streams of SEWAGE

1.Koramangala and Challaghatta (K&C) Valley through Bellandur Tank (384-500MLD) → *the subject of this presentation*

2.Hebbal-Nagavara (180MLD) (K&C and H-N system are inter-linked of chain tank system earlier made for storm water and now sewage flows through each of these chain lakes)

3.Vrishabhavati Valley (500MLD)

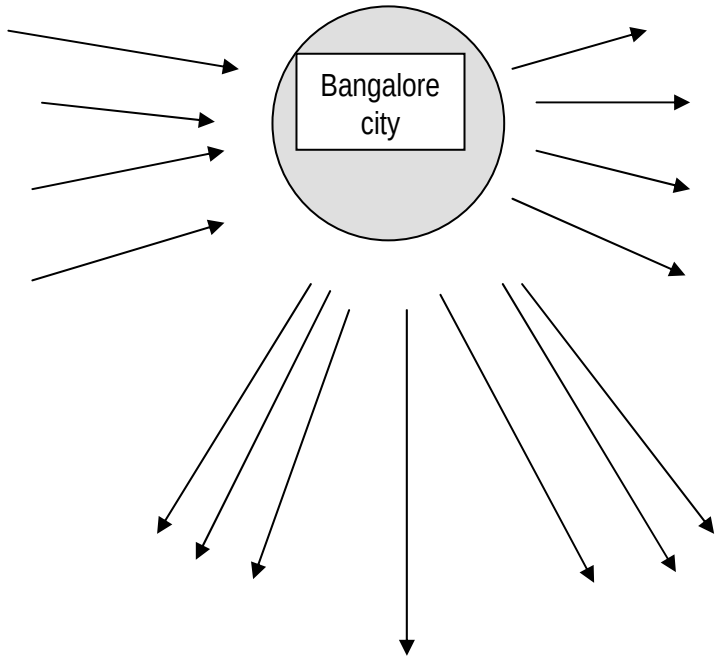
Soak pits into ground water (not estimated) generally in the peripheral areas



## 4-modes of C and N entering the ecosystem and its components

a. entering underground sewage lines and carried away by sewerage system, finally entering various lakes
b. discharged as sewage but into house hold level soak-pits,
c. subject to open discharge (open defecation in case of human beings) and
d. subject to composting – more of animal wastes and very little of human waste (experimental).

INFLUX
Human excreta (residential) (51.6t)
Human excreta (floating population) (10.9t)
Animal excreta (major) (12.3t)
Animal excreta (minor) (2.0t)



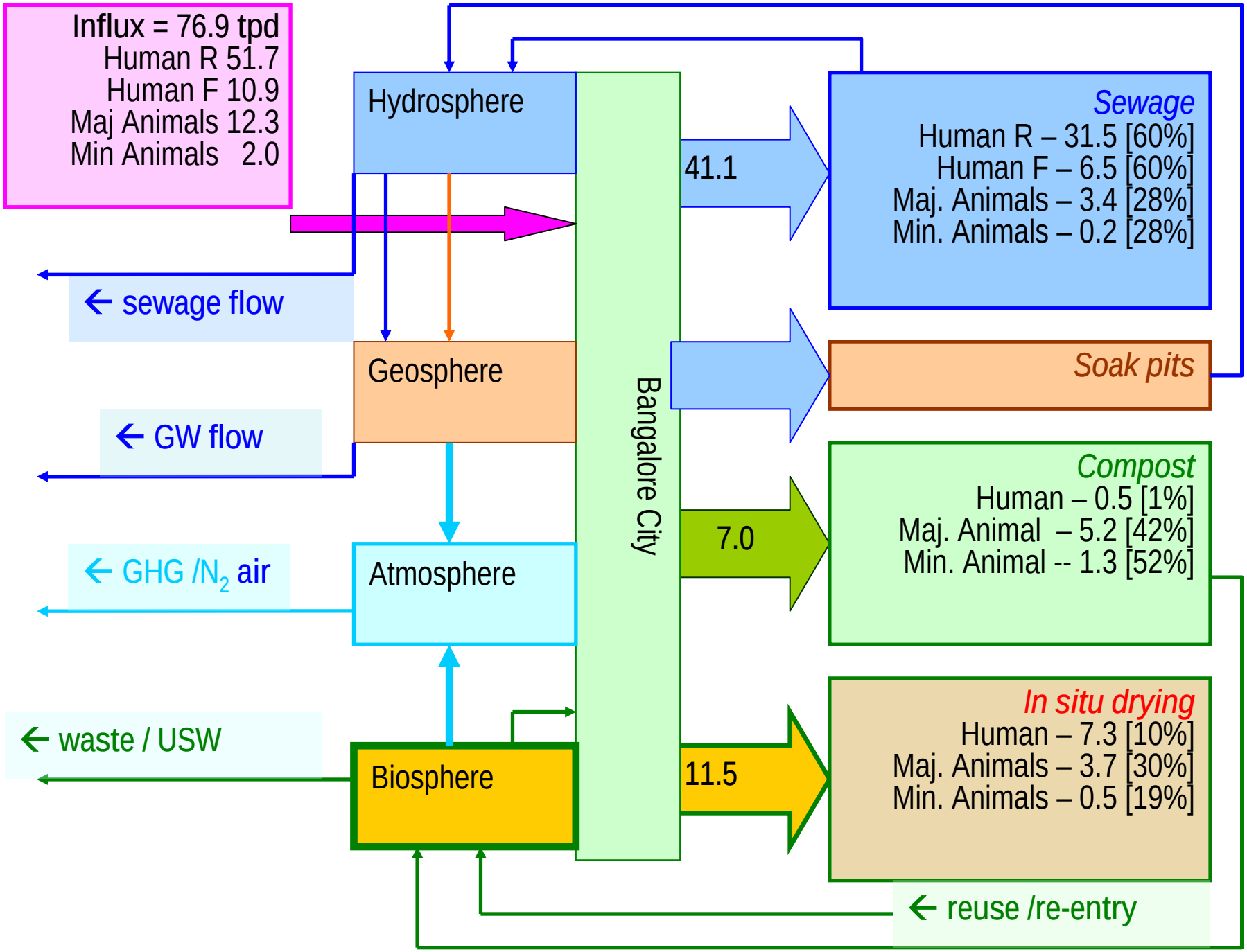

EFFLUX
Human residential (60%, 31t)
Human non-residents (60%, 6.5t)
Major animals' waste (28%,3.4t)
Minor animals' waste (9.7%, 0.2t)

Efflux continued →
*in situ drying*
(10%, 7.3t human wastes)
(30%, 3.7t, Major animals)
(19%, 0.5t, minor animals)
soak pits

Composted
(1%, 0.5t human waste)
(42%, 5.2t Major animals)
(52%, 1.3t Minor animals /birds)

Human waste from residents (29%, 18.1t)

# Fraction of wastes and mass of N flowing through Bangalore


Influx = 76.9 tpd
Human R 51.7
Human F 10.9
Maj Animals 12.3
Min Animals 2.0
Hydrosphere
Geosphere
Atmosphere
Biosphere
Bangalore City
← sewage flow
← GW flow
← GHG /N2 air
← waste / USW
41.1
7.0
11.5
Sewage
Human R – 31.5 [60%]
Human F – 6.5 [60%]
Maj. Animals – 3.4 [28%]
Min. Animals – 0.2 [28%]
Soak pits
Compost
Human – 0.5 [1%]
Maj. Animal – 5.2 [42%]
Min. Animal -- 1.3 [52%]
In situ drying
Human – 7.3 [10%]
Maj. Animals – 3.7 [30%]
Min. Animals – 0.5 [19%]
← reuse /re-entry

Human and animal waste (faeces + urine) → total 77tpd = 28,105 t/yr

Urban solid wastes (USW, open dumping) → 18tpd, 6570tpy

Composting and fertilizers (urban landscaping) → 3.75tpd, 1370tpy

(300tpd@1.25%N)

Crude anthopogenic intervention →36045tpy / 60000ha

= 600kg N/ha deposition rate

# The Problem

If we consider the area of Bangalore as 250sq km (the densely populated area) we get a deposition of 1500 kg N /ha/yr. This is very high deposition rate and will lead to N contamination because the deposition rate outstrips the natural processes for N cycling.

Table – DM and N flows in Bangalore and Bellandur lake

| Source | DM | Sewage fraction % | OM in sewage | Urine N | Excreta N | Total N | total to sewage |
|---|---|---|---|---|---|---|---|
| Human | 372 | 88 | 327.4 | 51.4 | 11.2 | 62.5 | 54.7 |
| Major animals | 392 | 30 | 117.6 | 7.0 | 5.3 | 12.3 | 3.4 |
| Minor Animals | 37.5 | 25 | 9.4 | NA | 2.0 | 2 | 0.3 |
| Total | 805 | | 454.4 | 58.4 | 18.5 | 76.8 | 58.4 |
| Bellandur Lake | | | 109.06 | | | | 14.02 |

Of the C efflux, part of it is lost as above ground deposition, composting or into soak pits.

Among flowing sewage channels, 40:40:20 distributed into K&C valley, Vrishabhavati and Hebbal-Nagavara systems.

Table : Water composition of Bellandur lake 21-May-2005.

This represents downstream half of the lake. Data suggests that C decomposition is complete before it reaches this stage and very small change in N transformations in this stage.

| Parameter | Jetty 1 | Diffuser 1 | Diffuser 2 | Diffuser 3 | Midlake | Jetty 2 | Diffuser 4 |
|---|---|---|---|---|---|---|---|
| COD mg/L | 80.00 | 79.47 | 79.65 | 79.30 | 80.18 | 80.18 | 79.65 |
| Cl mg/L | 115.33 | 115.73 | 111.32 | 112.92 | 115.73 | 112.52 | 115.53 |
| **$PO_4$ mg/L** | **0.41** | **0.37** | **1.06** | **0.46** | **0.29** | **1.33** | **0.89** |
| $NO_3$ mg/L | 2.18 | 2.39 | 2.70 | 2.38 | 2.20 | 2.14 | 1.84 |
| pH | 7.76 | 8.00 | 7.84 | 6.14 | 7.68 | NA | NA |
| Temperature | 28.4 | 28.4 | 27.8 | 29.8 | 28.1 | NA | NA |
| EC µS/cm | 950 | 956 | 950 | 934 | 947 | NA | NA |
| DO mg/L | 1.91 | 1.48 | NA | 6.43 | NA | NA | NA |

Table 2: Water composition of Bellandur lake 18 Nov 2006

| Parameter | Inlet Airport | Outlet Bellandur | Ground Water | Tap water |
|---|---|---|---|---|
| pH (1) | 7.35 | 7.96 | 6.97 | 6.9 |
| pH (2) | 7.38 | 7.96 | 6.99 | 7.65 |
| $NO_3$ mg/L(1) | 12 | 6.94 | 52.3 | 9.04 |
| $NO_3$ mg/L(2) | 11.7 | 7.33 | 60.2* | 6.29 |
| $NH_4$ mg/L | 31.4 | 31 | 6.37 | 30.1 |

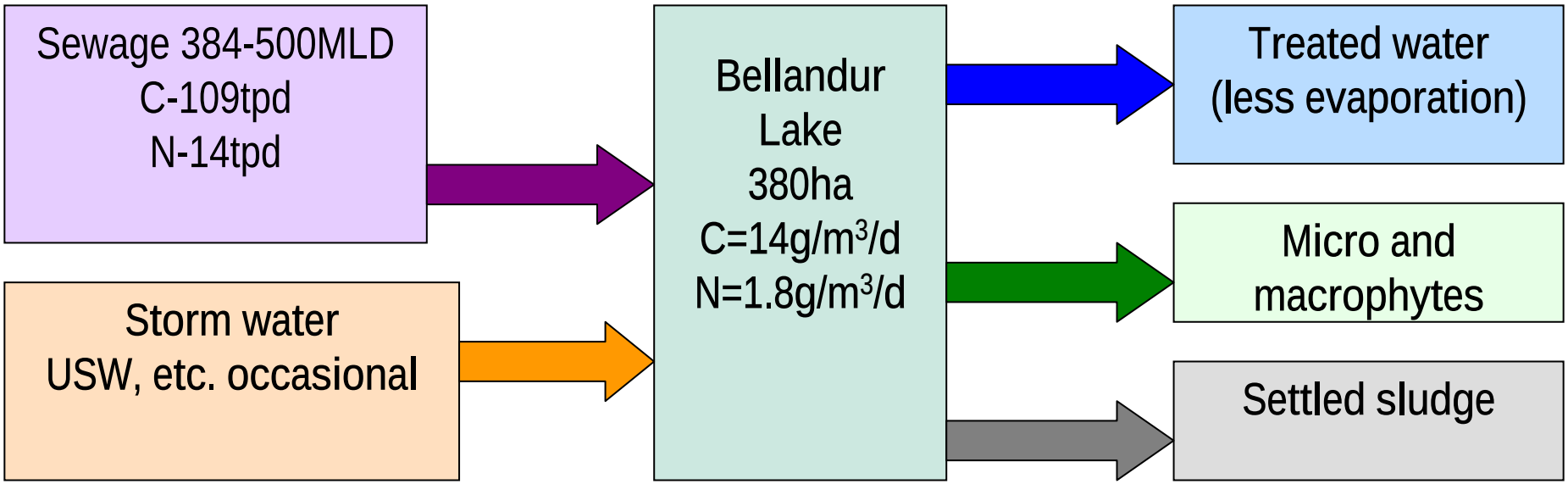
There are places where $NO_3$ of ground water is greater than 150mg/L

Few species
Low redundancy
Sustainability low

*Microcystis sp*

*ostrocods*

*Pediastrum*


Sewage 384-500MLD
C-109tpd
N-14tpd
Storm water
USW, etc. occasional
Bellandur
Lake
380ha
C=14g/m3/d
N=1.8g/m3/d
Treated water
(less evaporation)
Micro and
macrophytes
Settled sludge

Lake area c.400 ha, seen is about 10% of lake area

Inlet from Indiranagar – SW park

Inlet-1 into the lake – airport side

Inlet-2, Agara lake side

Lake surface, c.15% covered by macrophytes

# Where problems have surfaced

## Three locations -

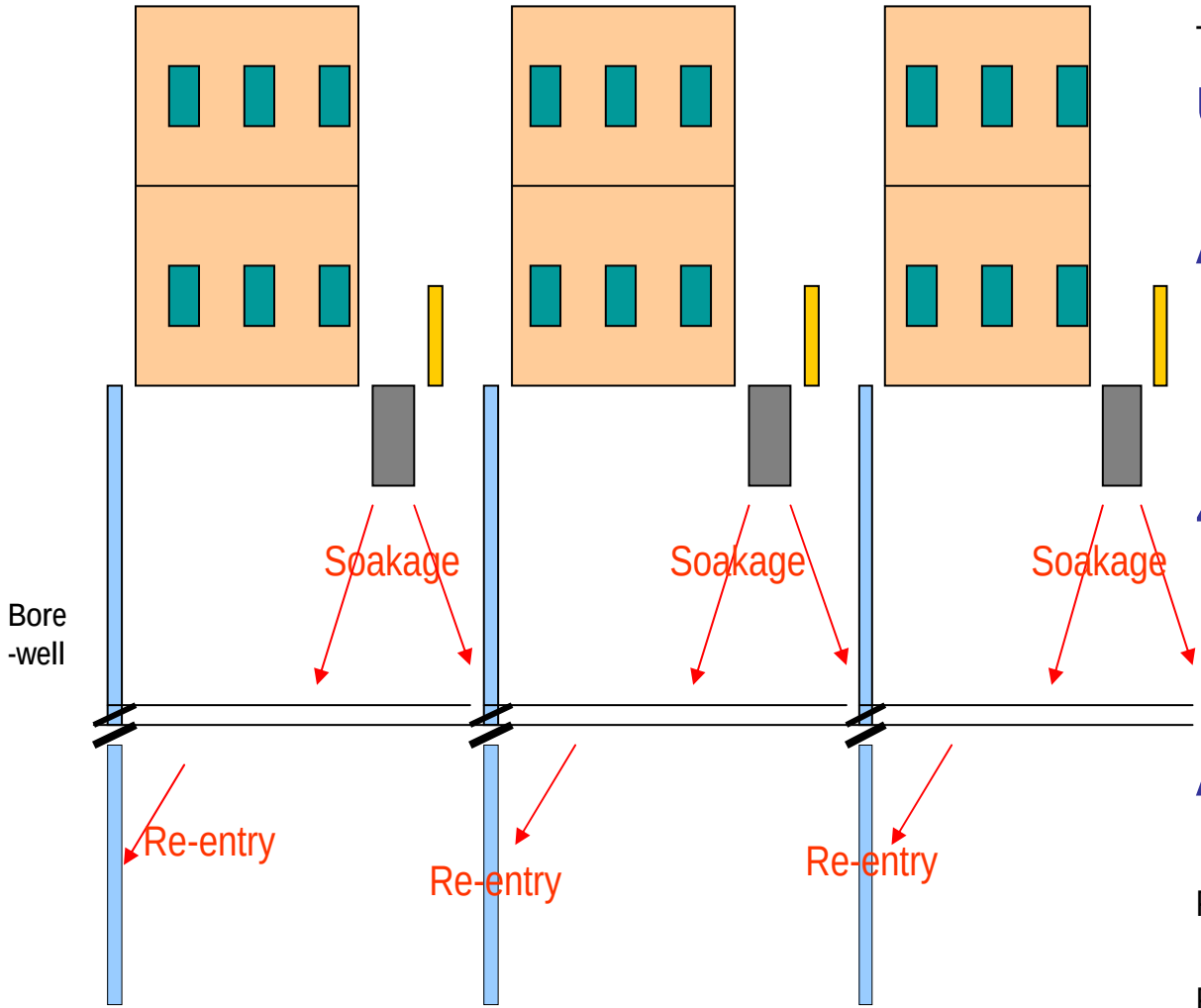
Peri-urban - Strong flows of sewage and will be the major source of recharge -->

Rural - Water with high bacterial load - entering tanks and recharged rapidly

Urban - borewell (water source) and soak-pit /sewage proximity –

1-9m apart ≥10yr exposure to $10^3$ higher bacterial load/pathogen risk - higher coliform diarrhoea and new pathogenic species, *15-20m travel though soil inadequate for safety – 60-200 mg/L $NO_3$ groundwater – Smaller molecules (Pharmaco-biotics) →→→ NEW Research*

# Where problems have surfaced - peripheral areas




Three locations -

Urban - borewell /open-well and soak-pit proximity

All attempt a 50-70ft separation between soak-pit and well - soil travel to consider water safe afterwards.

40% of urban water comes from sub-soil/ ground water resources - easily contaminated by the above.

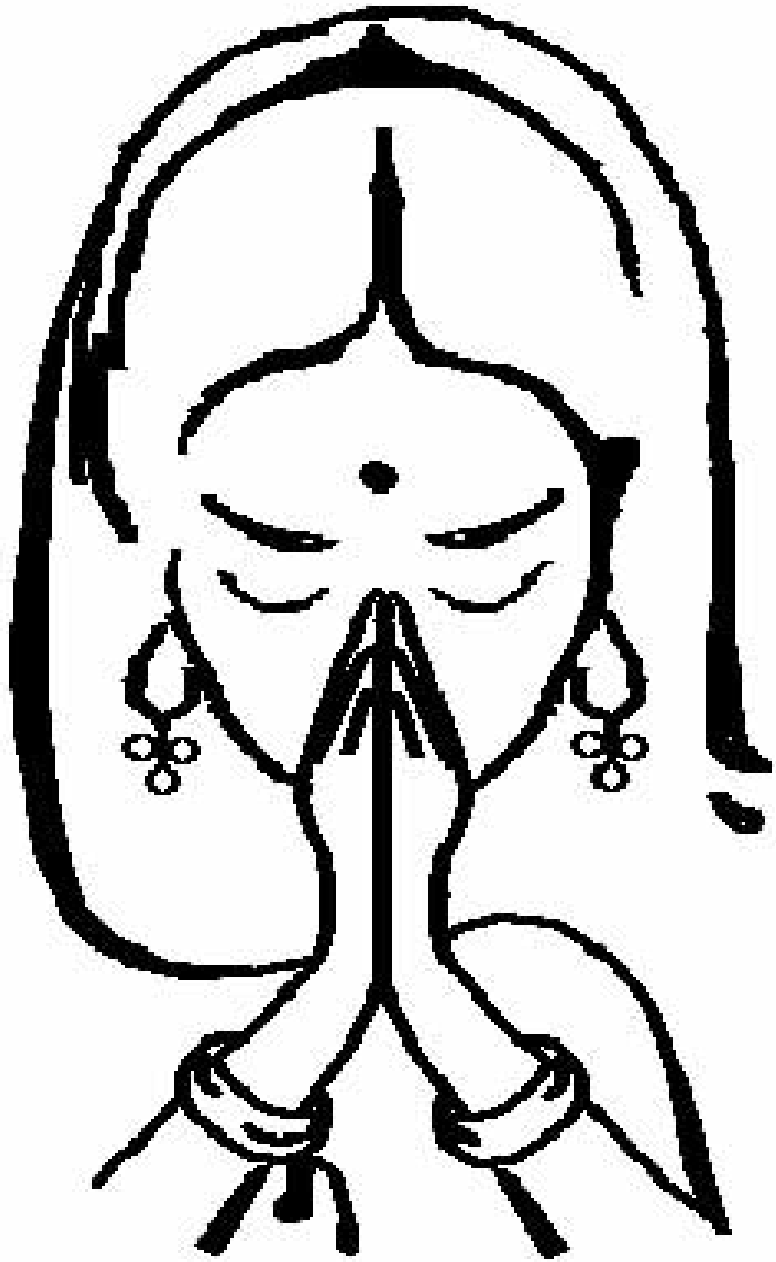
All fringe areas wait >10yr for safe urban water supply.

Peri-urban - Strong flows of sewage and will be the major source of recharge

Rural - Water with high bacterial load - entering tanks and recharged rapidly

# Conclusions

- Loading @C=14g, N=1.8g/$m^3$/d, Threshold yet to be determined and will be season based, higher in summer and lower in monsoon
- C removed efficiently but deposits sludge upstream and needs to be addressed – else capacity will gradually reduce
- Nitrification limited, nitrate removed (needs to be partitioned into denitrification and uptake
- Macrophytes need to be restricted
- The system appears limited by phosphate availability – further tests needed to understand where it is going /locked up
- With growth of city plan should be towards decentralized anaerobic sewage treatment – reduce C load into lake and use it for N and P moderation.



Thank you