APPENDIX 1 A: WATER DEMAND

Section A: Water Usage at all the End use locations in the School

NOTE:

- The school does not have any water meter. So, we devised our own methods to calculate the water demand in school.

- The survey was originally planned for a period of 4 days (24th, 25th, 28th and 29th of October, 2013). The data collected from the first day was ignored due to errors in inputting the water consumption numbers by the students.

- Buckets and mugs used in the toilets/cleaning areas were standardized. The mugs of capacity ¾ and 1 ½ litres respectively were used in the toilets. The mugs were also marked for usage at ½ l and ¼ l.

- Sample Size:

Table 3.1: Total sample size

Section/Building	Sample Size
Primary	6 - (students + adults)
Nursery	7 - (students + adults)
Middle school	9 - (students + adults)
High school	17 - (students + adults)
Administration	8 - (adults only)
Total	47

Data collection and preliminary Analysis

Toilets: Water is used for flushing, hand wash and cleaning. We had a sample group of volunteers who marked the datasheet posted in the respective washrooms in each of the buildings on the aforementioned dates.

- Based on the analysis of the data, we calculated the average per capita daily consumption of water across the entire school.
    - For example: in the primary section:

  Number of tally marks for hand wash (.5 l mugs) =22

  Number of tally marks for toilets (1.5 l mugs) =11

  Sample size = 6 (refer to table 1.1)

  Per capital consumption = (22*0.5+11*1.5)/6=4.5 l

Kitchen

- Drums with a capacity of 75 litres were used in the kitchen for calculating the water consumption.
- The drums contained water for washing vegetables and preparation of food.
- The canteen co-coordinator and staff marked the number of drums used in the datasheet put-up. The drums were refilled as and when required.
- Then we calculated the data the following way:
  Total consumed = No. of tally marks * capacity of drum

  Total consumption=4 *75= 300l

From this we calculated the per capita consumption for the whole school.

Dining area

- The same sample of staff and students was used. We used a 0.75 l mug for calculating how much water was used during lunch and snack break. (Refer Table 3.1).
- Water is used in the canteen at three levels.

  Step 1: dipping the plates in warm water to remove the food particles. This would help in recycling of waste water.

    - Two containers of capacity 20 l are kept in three different locations (in the dining room) which are refilled 4 times a day.

- The total consumption from this end use was calculated as follows:
  - Consumption = capacity of containers x number of times refilled x number of containers
- The average was calculated.

Step 2: Washing plates and other utensils by students or staff.

- Mugs of capacity ¾ l were used for this purpose. The mugs also had markings at ½ l and ¼ l.
- We followed the methodology that we used for calculating the consumption of water in toilets, for this purpose also.

Step: 3 Re-washing of the plates by the *Ammas*.

- All the plates and utensils rinsed by the children are again washed by the *Ammas*
- The methodology for calculating water consumption in kitchen was followed here too!

Water for Drinking: Water drums of capacity 20l are placed in the following sections in the school:

- Primary lobby
- Administration
- Middle school lobby
- High school lobby
- Nursery lobby

- Total consumption = Capacity of the drums x number of times refilled.
- Average was calculated

Garden: The data we collected is based on the estimates given by various sources. We talked to the garden co-ordinator, the gardener, the campus manager and others concerned.

Table 3.2: Water usages in the garden

Amount of water used	**Source**	**Where?**
800 litres	Bore well	up to football field
500 litres	waste water recycle	herb garden (admin)
300 litres	Bore well	herb garden again near admin
3500 litres	waste water recycle	vegetable garden
5000 litres	Bore well	main vegetable garden

Garage: Buckets of capacity 20 li are used everyday to clean the 8 buses we have.

Consumption was calculated as follows: capacity of buckets x number of buses
Average calculates as required.

Over all cleaning and mopping: We put up data charts on:

a) Primary lobby
b) Nursery lobby
c) Middle school lobby
d) High school lobby
e) The administration building lobby
f) The canteen lobby

- The Ammas filled the data sheet according to the no of buckets of water
- They filled the charts again using the tally marks.
  - Calculation: (the capacity of bucket * no of bucket used) and the adding up all the data for each block.

- **Leakages**: We found the places where there are any leakages which were-

Table 3.3 Leakages

Place	Number of taps	Water leaked (in ml)	water leaked in Litres	Per day
Kitchen	1 loose water tap	12 ml/min	0.012 l	17.28
Admin	1 tap	11 ml/min	0.002 l	15.84
High school	1 tap	23 ml/min	0.023 l	33.12
			TOTAL =	66.24

Section 2: Analysis

Chart 3.1

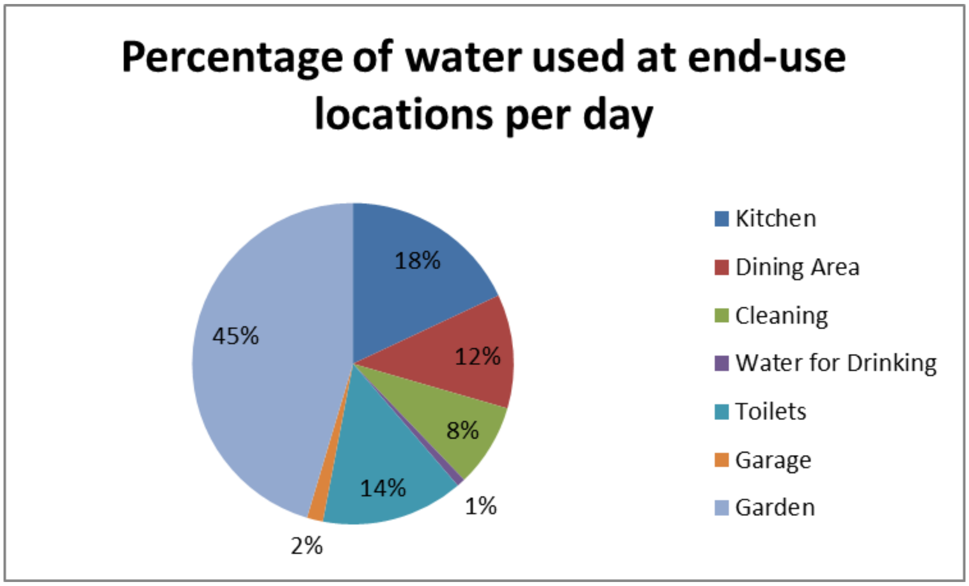


Table 3.4 Annual water consumption

Days		Total population	water demand/day	total water demand on working days (litres)
Total number of working days	200	704	22,258	445160
Number of working Saturdays	20	151	4,832	96640
Number of national holidays	15	0	0	0
Summer + Christmas + Dussera	130	65	2,080	270400
Total = 8,12,200 litres				

APPENDIX 1 B: WATER TRAIL

B.1 Bore well

Our school draws water from a bore well. It is present at the end of the campus adjacent to the basketball court (see map attached). The depth from which water is drawn is 360ft. However, in the beginning of 2000, the school was getting water at a 220ft depth. This year due to heavy rains, the water table has raised ad we are getting water at a 110ft depth.

The recharge pit is helping a lot in bringing up the water table. During summers we use the pump more often. The brand of the pump is Suguna, a submergible pump and it requires 5 to 7 units of electricity for 1 hour. The amount of water we need is20 to 30 thousand litres. By switching on the pump for 12 hours per day we can get 30,000l. It pumps up 3,000- 4,000 l per hour. In 10 hrs it will consume 50 units of electricity and each unit cost Rs. 3 and 10p.

The quality of the bore well water is salty. Daily average amount of volume we pump up is 18,590 litres.

- **How is ground water given to the whole school?**
  The water from the groundwater is stored in overhead tank. From there it flows to all the other blocks which each in turn have tanks of its own. The bore well water does not go through any filtration (see map attached).

B.2 Rainwater harvesting

Rain water harvesting happens in all of our school blocks (middle and high school, primary and admin blocks). The water from each of these rooftops flows into their respective tanks from where it is circulated all over school (see map attached). For the capacity of these tanks all around school, see map attached. The rain water goes through filtration. The method in which we set up the filters are- For every 1000sq.ft there is 100ls capacity filter. The overhead tanks are 30ft under ground level for better pressure due to gravity and the main tank is placed 30ft above the terrace.

- Filtration of the water:
  The water collected on the terrace goes through a 100l filter tank. The filter has 60% of free space for water to pass through. The remaining 40% had many layers of big jelly (40mm), mesh, medium jelly (20 mm), mesh, small jelly (10mm).
- Changes in pattern of rainfall:
  Bangalore receives the most rainfall every year during the months of June, July, August and September. There are light showers during the other months, except for November, December and January.
  How rainfall flows in the school campus:

The Recharge Pit is present at the end of the campus and is the lowest point, thus a majority of the rainwater flows into it, helping in bringing the water table up. The overflowing water also goes to the recharge pit via pipes (see map attached).

- The quality of rain water is good and can be used for all purposes except drinking. It is filtered as already mentioned.

Below is the table which is how we found out the rain water harvesting potential and how much water we currently use. The amount of rainfall our school region receives annually is 800 mm.

Table B.1 – Amount of rainfall we get in our school

Type of surface		Measurement	Total	Coefficient	Harvesting	Result in kilo litre
Roof	Admin, Primary, Middle and High, Nursery	1750+ 812+128+105	2795	0.9	2795*0.9*0.8	2012
Hard	Football Ground, Basketball Court, Throw ball Court, Sandpit	2040+ 375+162+320	2897	0.4	2897*0.8*0.4	927.04
Soft	Remaining school	10,964	10,964	0.4	10964*0.4*0.8	3508.48
Forest	Devar Kadu, Long jump pit	1044+36	1080	0.2	1080*0.2*0.8	172.8
Hard & soft	Amphitheatre	475	475	0.6	475*0.6*0.8	228
Total			18,211			6848.64

Table B.2: Area of various surfaces

Roof	**1750**
Football Ground	2040
Basketball Court	375
Throw ball Court	162
Long jump	36
Amphitheatre	475
Stage	105
Deck	128
Nursery	812
Devar Kadu (Sacred forest)	1044
Sandpit	320
Total	**7247**
School	**18,211**
Remaining	**10,964**

- Rain water harvesting:
- Volume of rainfall harvested annually: 1260.216. Rainfall received annually: 800mm.

Terrace measurements:

1. High and middle school – 11,127ft
2. Admin – 5250ft
3. Primary – 2463ft

- Rainfall endowment:

0.8*18211

=14568.8kl

- Rain water potential:

Total rainfall endowment*runoff coefficient

1) 812+1750+128+105=2795

2795*0.9*0.8 = 2012.4kl

2) 320+2040+162+375 = 2897
   2897*0.4*0.8 = 927.04kl
3) 1044+36 = 1080
   1080*0.2*0.8 = 172.8kl
4) 475*0.6*0.8 = 228kl
5) Total amount:

Black water trail:

The water filtered by the black water is used in the garden for the plants. The water which is treated is from the canteen and the kitchen.

We generate up to 3000 to 5000 l per day.

The filter for the black water trail is as follows-

We use aggregates of 40 mm, 20mm and 10mm of jelly rocks. We do not use soil due to two reasons-

1. When the water passes through soil, the small particles of the soil also flow out with the waste water and in turn making it dirtier.
2. The soil particles are so tightly packed that there is a possibility that the water will not even go through the filter. Hence in our filter we use stones of the above measurement than soil or even sand.

Design of Water Trail

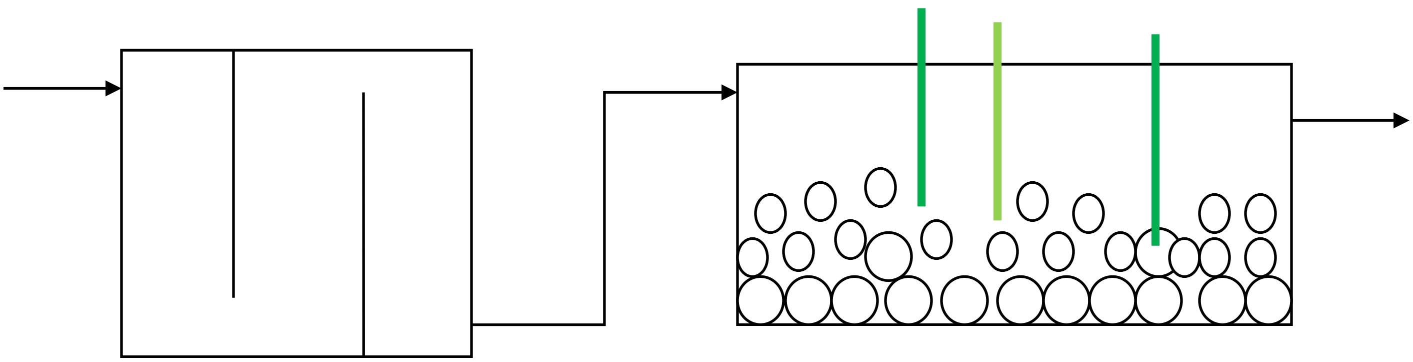
In our school, we don't have a complete waste water cleaning trail.

The water from the canteen goes directly to the settling chamber of the black water trail, which has 3 compartments. The solids settle down and the water is left with very less organic solids. Foam from the soap nut in the water floats at the top of the chamber from where it is manually removed once a week. The water then goes into the reed belt chamber. The chamber is laid with kadappa stones. It has a planted gravel filter. The plants are hydroponics –they don't grow in soil, their roots catch soap sulphates and phosphates and oil .The stones are of 40mm, 20 mm. The plants used in our school are jumbo, reech. In our school we don't have the third chamber wherein the water undergoes filtration, therefore our schools black water still has some salts, organic matter and bacteria. But then the water is good enough to water plants. Currently our waste water is still black water but we aim to make it grey water. Two things to do so are –

- Using soap nut instead of soap
- Dipping the plates in water before washing so as to remove excess organic matter.
- Quality of grey water:

  The grey water is smelly and grey in colour. It also has biological matter thus it is used for garden only. Plants are not affected with this water as it is we do not use chemicals for cleaning the dishes.

Fig B.1 -Water from the canteen



Settling chamber **Hydroponics plants do not need soil to grow in.**

The root system catches oil, soap, SO_4, PO_4

Solids settle to the bottom.

Scum remains on the top.

The water then which comes out has little salt, organic waste and bacteria. It can be used for only watering the plants.

The end uses of all the water are:

1. Primary
2. Canteen
3. Nursery
4. Admin
5. Garden (majority of water)

Quality and its issues

The water smells are there is still biological matter in it. It can be used for plants and nothing else. The plants are not affected as we don't use chemicals and only a natural soap like substance called soap nut.

Waste water from our school goes into septic tanks. There are septic tanks specifically for each block (see map attached). The only waste water we produce is that from the toilets and from general cleaning. This goes into the septic tanks which have a storage capacity of about 3000 l. once these fill up in about 15- 20 years; the municipal people pump this waste out. The reason why the septic tanks take so long to fill is that it is constructed in such a way that the water is left to percolate out into the soil. Thus the solid waste remaining is the size of a matchbox.

The below table is for the amount of waste water generated per day.

To minimize the amount of waste water we generate, we need to educate people on how to save water in easy ways. For example we have eco toilets which do not use even one drop of water. In the canteen we are using soap nut a substitute for the chemical detergents. Also we rinse the plates in a tub first to get rid of the organic matter and then wash it. This is our attempt to turn our waste in grey water rather than black water.

<u>Table B.3 – Amount of water consumed</u>

	Amount of water consumed (in litres)
Toilets	2,679
Cleaning	1,848
Total	4,527

<u>Additional information</u>

- Total school campus area= 4.5 acre = 18211 sq. m
- Total water capacity we have for rain water= 28,500 l

APPENDIX 1 C: WATER QUALITY

Samples Collected

We conducted various experiments on the following water samples

- Tap water: Collected from the bore well
- Drinking water: Bore well water which is purified via an aqua guard
- Black water: Kitchen waste water which is recycled in the Black Water Plant
- Pond water: From the school pond
- Rain water: Collected in several rain water harvesting tanks located all around the school campus

Table C.1- Physical Parameters

Physical Parameters	Tap Water	Drinking Water	Black Water	Pond Water	Rain Water
Colour	Clear	Clear	Greyish black	Muddy	Mostly clear
Odour	Odourless	Odourless	Pungent, stinky odour	Odourless	Odourless
Turbidity	Clear	Clear	Very turbid	Slightly turbid	Slightly turbid
Suspended Solids	None	None	Suspended living matter like worms and leaves	Dirt, leaves, living matter like worms and tadpoles	Few suspended particles like mud and dirt
Temperature	24 °C	23 °C	23 °C	24 °C	24 °C

Table C.2-Testing the pH of Water

Aim	To find out the pH of each water sample
Method	▪ Take a leaf from the pH paper booklet. ▪ Dip it in the water sample. ▪ Compare the colour to the colour reference chart. ▪ Record it.
Observation	▪ pH of Tap Water: 7 ▪ pH of Drinking Water: 7 ▪ pH of Black Water: 8 ▪ pH of Pond Water: 7 ▪ pH of Rain Water: 7
Conclusion	<Pending>

Table C.3-Testing for Total Solids

Aim	To test tap water for total solids
Method	▪ Weigh an empty beaker. ▪ Fill it with water (50 ml) and weigh again. ▪ Heat the beaker till all the water evaporates. ▪ Weigh the beaker and note the increase in weight
Observation	▪ The weight of the empty beaker is 103.8 g ▪ The beaker with 50 ml of water weighs up to 147g ▪ The beaker after all the water had evaporated weighs up to 107.7 g ▪ Therefore, Total solids = 107.7-103.8= 3.9 g ▪ The total solids formed a thin white coating around the bottom and sides of the beaker, there was also a bit of yellow in the middle.
Conclusion	The amount of total solids in 50 ml of water was 3.9

Table C.4-Bacteriological Contamination

Aim	To find out the amount of pathogenic bacteria in ▪ Tap water ▪ Rain water before SODIS ▪ Rain water after SODIS ▪ Black water before SODIS ▪ Black water after SODIS
Method	▪ Pour out the above stated samples into 5 different Aqua Check Vials* ▪ Leave each sample undisturbed for 24-48 hours ▪ Check the colour of each vial and compare with the standard chart given in the water testing kit
Observation	▪ Tap water turned Greyish Black ▪ Rain water before SODIS turned Black ▪ Rain water after SODIS turned clear Brown ▪ Black water before SODIS turned Inky Black ▪ Black water after SODIS turned Black
Conclusion	Tap water, rain water before SODIS and black water before and after SODIS are not fit for drinking as they contain pathogenic bacteria. Rain water after SODIS can be drank after purification as it contains minimal pathogenic bacteria

Water Purification

We conducted four experiments for water purification – filtration, coagulation, sedimentation and decantation.

Table C.5-Filtration of pond water

Aim	To filter pond water
Method	▪ Take a filter paper and put it in a funnel and hold the funnel over a beaker ▪ Pour 75ml of the water sample through the funnel ▪ Collect the filtrate in the beaker bellow
Observation	Most of the suspended insoluble particles have been filtered out and the colour of the pond water is more yellow than brown
Conclusion	Pond water can be filtered and used.

Table C.6-Coagulation of pond water with alum

Aim	To sediment the solid insoluble particles in pond water
Method	▪ Take a beaker of 75ml of pond water in a beaker and put alum in it. ▪ Leave the beaker undisturbed for 10-15 minutes
Observation	Most of the particles settle down
Conclusion	Alum coagulates pond water

Table C.7- Sedimentation and decantation of black water

Aim	To purify black water
Method	▪ Take a sample of 200ml of black water in a beaker ▪ Leave it undisturbed for around a week and half. ▪ Pour out the water making sure that the sediments at the bottom remain untouched.
Observation	▪ The water collected after the experiment is much less turbid and is almost clear. ▪ It does not smell anymore
Conclusion	The water obtained after the experiment is much cleaner and clearer.

Table C.8-Purification of water by SODIS

Aim	To purify rain water and black water by SODIS
Method	▪ Put each of the samples in PET bottles and leave in direct sunlight for 6 hours.(this is so that the U.V. rays of the sun can kill pathogenic bacteria ▪ Retest the water samples in Aqua Check Vial*

Observation	The black water still turns black in the Aqua Check Vial indicating the presence of pathogenic bacteria. The rain water turns a clear brown indicating less pathogenic bacteria
Conclusion	SODIS can kill pathogenic bacteria in rainwater.

Note: *The Vials were provided by Jal-TARA Laboratory