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# Identify the Causes and Environmental Friendly Methods to Control Eutrophication in Vavuniya Tank, Sri Lanka

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**ABSTRACT**

*This research was carried out to identify the main courses for eutrophication by measuring Nitrate and Phosphate level at different location in Vavuniya tank and to identify the main* algae *species of and find out environmental friendly methods to control eutrophication. Water samples were collected from eleven locations in Vavuniya tank by using water sampler at the depth just below the water surface. Locations were marked by coordinates using GPS and samples were collected once in two months from July to November 2011. The* $NO_3^-$ *was significantly (p=0.053) higher in November than July due to runoff water from different land (agricultural land, waste disposed land) after heavy rain. But all the values were below WHO permissible limit of 10 ppm. Phosphate values in all samples except S4 were above the WHO drinking water standard permissible limit of 2 ppm of in July 2011 and also all the samples except S1 were above 2 ppm in November 2011. Samples S3, S5, S6, S7 and S8 showed higher* $PO43^-$ *value than other locations. These are main non-point sources of pollutant to Vavuniya tank and cause eutrophication. Therefore action has to be taken to minimize pollutant coming to Vavuniya tank from these location Eichhornia crassipes and Polygonum barbatum were the common eutrophication species in Vavuniya Tank and spread of these species can be minimized by participation of all (Fishing community, Department of irrigation, Environmental Officers, UC and other stakeholders). Polygonum barbatum has an antimicrobial activity and further study has to be carried out to confirm the antimicrobial effect of above weeds in Sri Lanka to be used as bio-pesticide.*

***KEYWORDS****: Eutrophication, Fishing community, Eichhornia crassipes, Polygonum barbatum.*

## Introduction

Vavuniya tank is located in the Urban Council limits of Vavuniya district, comes under the Minor-tank category. Recently, it paid attention due to the green color mat (Eutrophication) present on the surface. Eutrophication is enrichment of nutrient specially nitrogen and phosphorus in water bodies that promote proliferation of plant life. Nutrients leading to unwanted plant growth which cover the water surface and narrow-downs water-air interface leads to reduced dissolved oxygen and sun light penetration which are considered to be vitals of aquatic life.

Presence of this green mat, it became a nuisance to local freshwater fisherman community in interrupting movements of vessels, usage of fishing gear, a reduction in catch and causing dermal rashes and subsequent loss of livelihood. Willoughby *et al*. (1993) reported that, based on studies on the Ugandan shoreline of Lake Victoria, mats significantly depressed the diversity of fish species and fish biomass. Canals and freshwater rivers can become impassable as they become clogged with densely intertwined carpets of the weed. Haider (1989) suggested that the rate of water loss due to evapotranspiration can be as much as 1.8 times that of evaporation from the same surface but free of plants. This has great implications where water is already scarce.

Although the direct effects are known and indirect effects of this green mat is numerous and un-ignorable as it may affect habitat diversity, oxygen concentration, and species diversity of tank (Lei Zheng, *et al*., 2011). There is possibility of reduction in catch during a season and the fish may become unpalatable due to the presence of toxic chemical. The research was performed for the purpose of identifying the causes for eutrophication, main species for eutrophication and environmental friendly methods to control eutrophication in Vavuniya tank.

## Methodology

### *Study Area*

The study site Vavuniya tank is an aquatic body lies within the Urban Council limits of Vavuniya district. It is located in between N8˚45'13.75-53.21" E80˚30'7.50-59.23" geometrically. Wastewater and storm waters enter into tank through different drains which carry lot of nutrients (Nitrogen and Phosphate) from Industrial wastewater (S5, S6, S7 & S8), hotel wastewater (S2, S3, S4) and commercial wastewater (S3).

### *Collection of Water Sample*

Water samples were collected from 12 various locations (Figure 1) in Vavuniya tank using water sampler at the depth just below the water surface. Locations were marked by coordinates using GPS (Table 1). Samples were collected once in two months from July to November 2011.


**Figure 1: Sample Locations**

**Table 1: Sample locations and geographic coordinates (latitude/longitude)**

| Location | Coordinates | Description of location |
|---|---|---|
| **S1** | 8°45'34.80"N 80°30'20.00"E | Center of tank bund (North-side of Vavuniya tank) |
| **S2** | 8°45'15.981"N 80°30'08.24"E | Main drain canal, in front of Royal Garden Restaurant (West-side of Vavuniya tank) |
| **S3** | 8°45'16.172"N 80°30'08.19"E | Sub-drain enters into main drain (carries wastewater from small commercial food courts) |
| **S4** | 8°45'20.70"N 80°30'14.30"E | Main drain and sub drain mixing region of West-side of Vavuniya tank |
| **S5** | 8°45'01.791"N 80°30'28.30"E | Domestic drain enters into tank (Near, Horowapothana road side) |
| **S6** | 8°45'01.341"N 80°30'28.33"E | Industrial wastewater which enters into domestic drain |
| **S7** | 8°45'09.957"N 80°30'35.02"E | Another industrial wastewater enters into tank water |
| **S8** | 8°45'13.40"N 80°30'32.90"E | Mixing Region of S6 & S7 |
| **S9** | 8°45'38.30"N 80°30'41.40"E | East side of the Tank |
| **S10** | 8°45'36.77"N 80°30'26.36"E | Center of the Tank |
| **OL1** | 8°45'34.80"N 80°30'7.70"E | An outlet of Vavuniya tank in the North-side |
| **OL2** | 8°45'44.80"N 80°30'26.00"E | Another outlet of Vavuniya tank in the North-side |

### *Identification of Eutrophication Species*

Field visit was carried out to Vavuniya Tank with expertise to identify the dominant species for eutrophication. The morphology of the weed was used as a key in order to reveal the species. The species which was not identified in the field has been taken to Laboratory and identified with the help of expertise from other university.

### *Analysis of Water Sample*

Samples collected from each location were brought to Environmental Chemistry Laboratory (ECL) and analysis was carried to quantify the Nitrate ($NO_3^-$) and Phosphate ($PO_4^{3-}$) levels. Electrical conductivity and pH were measured by environmental prop and NO3- N was determined by colorimetric method using Brucine method (Taras, 1958). Nitrate-N analysis was done within twenty four hours after collection of sample. Phosphate analysis was carried out by Olsen method (Olsen, 1954). Significant different among treatment was` analyzed using t-test.

### *Data Collection from Fishing Community and Other Stakeholders*

Participatory Rural Appraisal (PRA), typically used in the field to gather community based quantitative data (Davis, 2001), was used to identify the importance of Vavuniya tank to the fishing community, causes and impacts of eutrophication and environmental friendly methods to minimize eutrophication in Vavuniya tank. Semi structured interview was carried out with individual fishermen, key informants and group of fishermen to collect above data. In addition, structure and maintenance of Vavuniya tank was collected from Engineer, Irrigation Department and Environmental officer, Urban council. Direct observation was carried out to see the causes for eutrophication from surrounding industries (Hotel, rice mill, small shops and market) and samples were collected to see the contamination.

## Results and Discussion

### *pH of Water Sample*

The pH of the sampled water varies from 5.33 to 8.51 from July to November (Figure 2). Samples S1, S2, S3, S4, S9, S10, Outlet1 and Outlet2 showed pH within the permissible limit of 6.5–9.0 (WHO, 1984) irrespective of the months. But S6 (Industrial wastewater), S7 (Industrial wastewater) and S8 shows pH value below 6.5 in July 2011 and water is slightly acidic. This range is not good for crop cultivation but pH value in Outlet 1 & 2 was within the WHO permissible limits due to mixing of water. Therefore, development of acidification in Vavuniya tank should be minimized by disposing industrial wastewater after treatment to control the development of acidity in Vavuniya Tank.

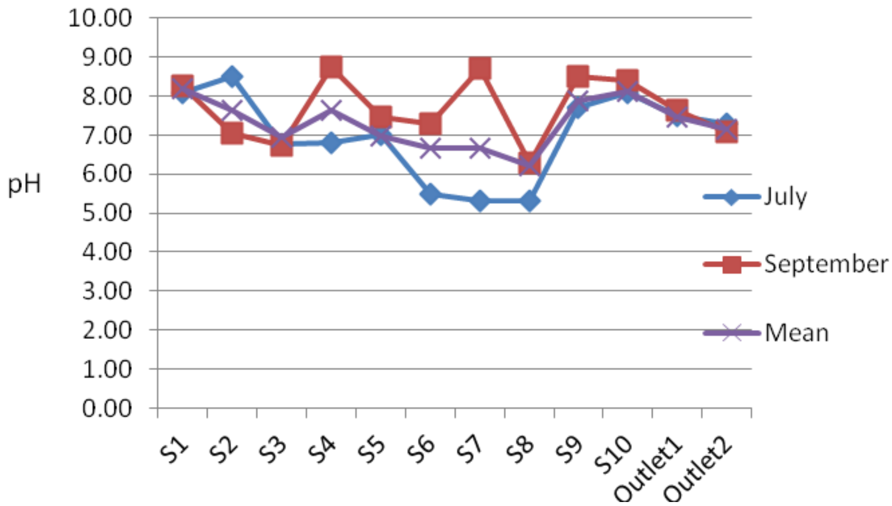


**Figure 2: Temporal and spatial variation of pH in collected water sample**

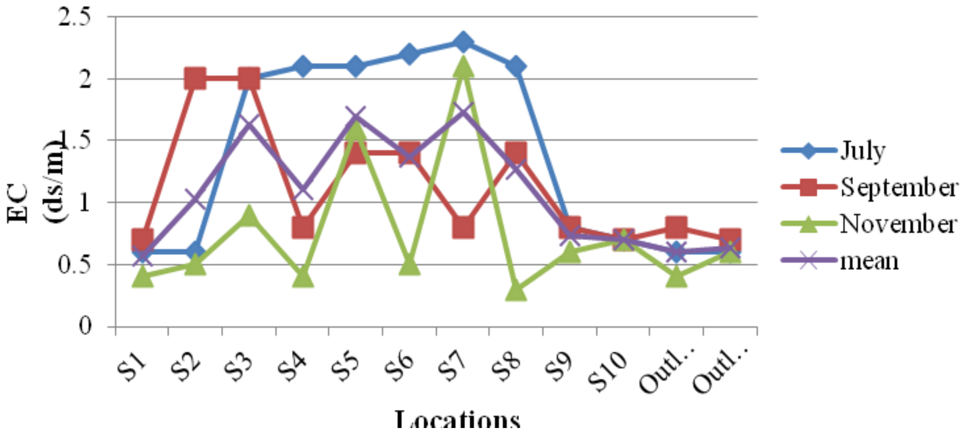


**Figure 3: Temporal and spatial variation of EC in collected water sample**

***EC of Water Sample***

Mean EC of water sample ranged from 0.57 to 1.53 $dsm^{-1}$ and it was within the permissible limit of 3.5 $dsm^{-1}$ (WHO, 1984) for drinking water. Therefore water could be used for drinking purpose without any health hazards in relation to dissolved salts. Electrical Conductivity of Centre of the tank (S10), Outlet 1, Outlet 2, East side of tank (S9) and Centre of tank bund of North (S1) were below 1.00 (0.8ds/m) for most crops. Rainy season (during November) value was significantly (p=0.01) less than dry season value (July) due to the dilution of dissolve salt by more flow of water into tank.

EC values were higher than desirable level for irrigation in locations S3, S5 & S7 (Figure 3) but water flow/movement of water in tank diluted these value as the EC value at outlets were near to the desirable level. Therefore, tank should be managed well to prevent further rise of EC level due to disposal of wastewater with solid particles/disposal of wastewater directly to tank without pass through oxidation pond.dsm$^{-1}$, in all seasons and these values were slightly lower than desirable level.

| Relative level | EC (ds/m ) | Effects on plants |
|---|---|---|
| Low | 0-0.4 | Too low, plants may starve |
| Medium | 0.4 - 0.8 | Good range for most plants |
| High | 0.8-2.0 | Slightly higher than desirable |
| Excessive | > 2.0 | Plants dwarfed and crop fails |

**Table 3: Level of EC and corresponding effects on plants**

***Nitrate Level in Vavuniya Tank***

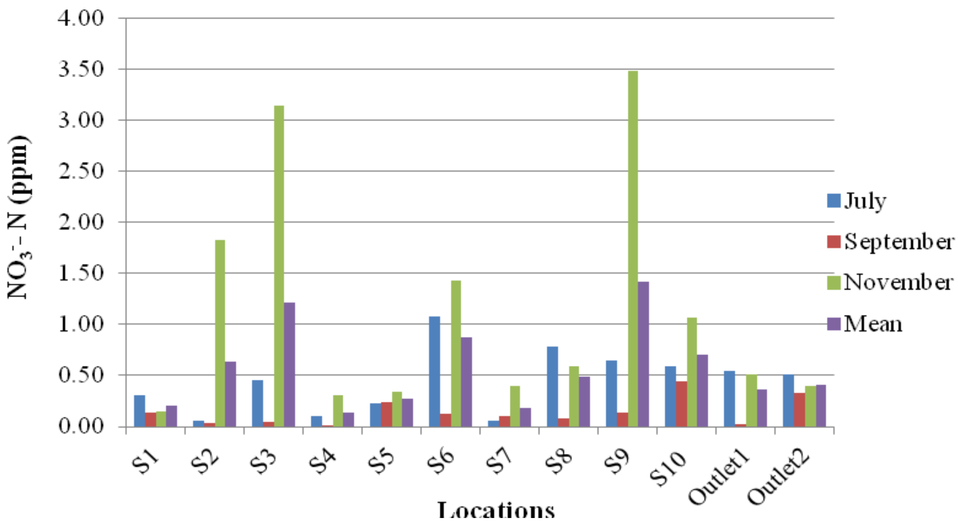


**Figure 4: Temporal and spatial variation of $NO_3^-$ *in* collected water samples**

The $NO_3^-$ ranged from 0.01 to 3.48 ppm from July 2011 to November 2011 and all sample values were below the permissible limit of 10 ppm of WHO drinking water standard. $NO_3^-$ in November was significantly (p=0.053) higher than July (Figure 4) value due to run off water from different lands (agricultural land, waste disposed land, etc) after heavy rain. The $NO_3^-$ value in S3 and S9 were higher than other locations in November 2011.

The $PO_4^{3-}$ ranged from 0.01 to 30.23 ppm from July 2011 to November 2011. All the sample values except S4 were above the permissible limit of 2 ppm of WHO drinking water standard in July 2011 and also all the samples except S1 were above 2 ppm in November 2011 (Figure 5).

***Phosphate level in Vavuniya Tank***

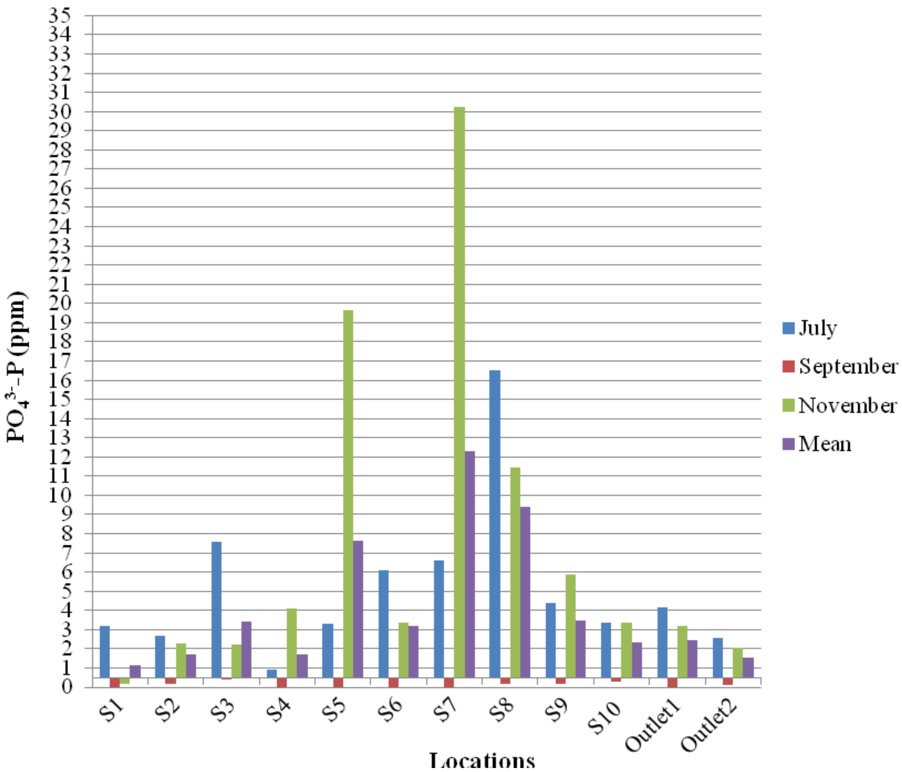


**Figure 5: Temporal and spatial variation of $Po_4^{3-}$ in collected water sample**

According to literature, in aquatic ecosystem, when exceeding 0.1 mg phosphorus per liter, biodiversity often declines with time. Samples S3, S5, S6, S7 and S8 showed higher $PO_4^{3-}$ value than other locations. These are main non-point source of pollutant to Vavuniya tank. There was no significant different in $PO_4^{3-}$ in November and July 2011. The runoff of nitrate and phosphate into tank causes accelerated eutrophication.

***Identification of Eutrophication Species***

Water hyacinth (*Eichhornia crassipes*) and *Polygonum barbatum* (Jointweed, Knotgrass and Smart-weed) were the common species in Vavuniya tank due to eutrophication during the study period in 2011.

Water Hyacinth (*Eichhornia crassipes)*

Water hyacinth is first abundant species in Vavuniya tank**.** Water hyacinth is a perennial aquatic weed that is usually free-floating. The plant reproduces by seeds and vegetative through daughter plants that form on rhizomes and produce dense plant beds.

According to the U.S Geological Survey (2003) two plants produced 1,200 daughter plants in four months. By this mechanism, water hyacinth can form impenetrable mats of floating vegetation. Individual plants break off the mat and can be dispersed by wind and water currents. A single plant can produce as many as 5,000 seeds and waterfowl eat and transport seeds to new locations. Seedlings are common on mud banks exposed by low water levels.

Water hyacinth infestations are associated with a variety of socio-economic and environmental impacts. Dense mats that block waterways inhibit boat traffic, damage fishing nets and hence disrupt trade, fishing and recreational activities Willoughby *et al*. (1993). And also health hazards to fishermen (skin irritation). They also clog irrigation canals. The thick mats reduce light penetration into the water, which causes a decline in phytoplankton concentrations that support the zooplankton-fish food chain, resulting in ecosystem changes.

Rotting material depletes oxygen levels in the water, further impacting aquatic biodiversity (Lei Zheng, *et al*., 2011). Seventeen fishermen use to catch fish in this tank and they use to prevent spread of water hyacinth by removing manually with participation of all relevant authorities (fishing community, irrigation department, farmers and other community people around who are polluting the tank).

According to fishermen, fishing nets are being damaged by water hyacinth but damage was less when comparing with 2-3 years back, as they use to remove the water hyacinth manually when they observe large mat of water hyacinth in tank. Accordingly, the Irrigation department performs the removal activity during Wednesdays in a week. Further they said that they had skin allergies in hand and legs after participating in a removal activity of water hyacinth.

Manual removal of water hyacinth is very labor expensive and time consuming as they consist 90 % of water in it. Misra and Triphaty (1975) reported that mechanical method of control is costly in time, money and energy and several of the procedures used damaged the ecology, affecting all animal life in the aquatic ecosystem infested by the hyacinth. Therefore removal should be done when they are in a small mat to prevent detrimental effect. Removed mat can be incorporated in a compost preparation.

Polygonum barbatum (Jointweed, Knotgrass, Smart-weed)

Second abundant species in Vavuniya tank is P*olygonum spp.* It is terrestrial or aquatic, perennial, erect herb, and grow up to 200 cm long. It reproduces by seeds and it is a weed in agricultural fields. Therefore agricultural field can be infested by these weed's seed during irrigation. Hence immediate action has to be taken to eradicate these weeds in Vavuniya tank. Queen Rosary Sheela (2011) showed in India that *Polygonum barbatum* has antimicrobial activity and leaf extract is a broad spectrum agent which can be used against gram negative and gram positive bacteria and also fungi. Further study has to be carried out to confirm the antimicrobial effect of above weeds in Sri Lanka to be used as bio-pesticide.

**Figure 6: Eutrophication species Polygonum barbatum**

**Figure 7: Flower of Polygonum barbatum**

***Status of Oxidation Pond in Vavuniya Tank***

The oxidation pond of Vavuniya tank was built by *GTZ* (German Technical Cooperation) in year 1995, consisting of two primary tanks and one secondary tank. Irrigation department and UC Vavuniya are the two bodies involved in the regulation of Vavuniya tank and its surroundings (Shanmuganathan, 2007). Now it is abandoned due to improper design and mismanagement (Shanmuganathan, 2007) and wastewater enters directly to the tank consequently it creates eutrophication.

***Environmental Friendly Methods to Control Eutrophication***

Fishing community said that they use to remove mat of plants manually when they observe a lots of mats in the tank (Figure 6). Therefore mat of plant should be removed when they observe in small in size as it is easy to remove and also to prevent further spreading. Fishing community further said that Irrigation department also uses to remove mats in every Wednesday. Therefore, Irrigation Department has to confirm the eradication of Eichornia crassipes and P*olygonum barbatum*. And also Irrigation Department has to confirm the flow of domestic drains to Vavuniya tank through oxidation pond to minimize the accumulation of waste into tank to reduce nitrate and phosphate pollution from non point source and confirm the regular function of oxidation pond.

Eutrophication could be controlled by regular maintenance of oxidation pond, tank and surrounding of tank and feeder channel by Engineers from Irrigation department, Environmental officers from Kachcheri & UC, fishing community and other stakeholders who utilize the water from tank.

**Figure 8: Prevailing situation in Vavuniya Tank – Eutrophication species Water hyacinth**

## Conclusions

Huge mat of Eichhornia crassipes and *Polygonum spps* were available in this tank due to the enrichment of nutrients ($NO_3^-$ ranged from 0.01 to 3.48 ppm, $PO_4^3$ ranged from 0.01 to 30.23 ppm) from non point sources (S3, S5, S6, S7 and S8). As livelihood of eighteen fishing families and many farming communities depends on Vavuniya tank, this is the good time to take remedial measure to prevent further development of EC, nitrate and phosphate pollution into Vavuniya tank using environmental friendly methods for the sustainability of tank. *Polygonum barbatum* could be used as bio pesticide after confirmation in field studies.

## Acknowledgement

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