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Potential to Grow Selected Leafy Vegetables in Kitchen Wastewater Hydroponics

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Abstract: In this study the potential of growing *Ipomoea aquatica* and *Alternanthera sessilis* in kitchen wastewater was assessed. Twenty one households were selected from seven areas of Jaffna Peninsula, Sri Lanka with three households from each area. Kitchen wastewater and respective ground water used in the experiment were analyzed in every week for nitrate N, phosphorous, potassium, calcium, pH and EC. Analysis of data was done by paired-T test and Duncan New Multiple Range Test (DNMRT) at significance level of 0.05. In ground water of the households the average values of nitrate N, phosphorous, potassium, calcium, pH and EC were 5.07±3.28 mg/L, 0.24±0.2mg/L, 16.55±4.79 mg/L, 30.85±8.16 mg/L, 7.33±0.16 and 1.36±0.37dS/m, respectively. In kitchen wastewater of these households average nitrate N, phosphorous, potassium, calcium, pH and EC were 4.08±2.72 mg/L, 1.71±1.01 mg/L, 13.89±9.59 mg/L, 35.96±6.17 mg/L and 7.65±0.27 and 1.47±0.76 dS/m, respectively. The average biomass increase of *Ipomoea aquatica* grown in kitchen wastewater was from 5.07 to 39.58g in three weeks. Biomass increase of *Alternanthera sessilis* grown in kitchen waste water ranged from1.92 to 21.33 g. It was concluded that *Alternanthera sessilis* and *Ipomoea aquatica* could be grown in kitchen wastewater hydroponic system which not only fulfills the family need of leafy vegetable but also efficiently use the kitchen wastewater.

Key words: *Ipomoea aquatica* · *Hydroponics* · *Kitchen wastewater* · *Alternanthera sessilis*

INTRODUCTION

Ground water is a scarce and important natural resource in the world. Population in Jaffna peninsula, Sri Lanka depends exclusively on the limited ground water resources to meet all of the water requirements. Ground water in Jaffna peninsula has been polluted by agricultural and non-agricultural practices. It has been reported that nitrate nitrogen in ground water is above the safe level in several areas in Jaffna [1, 2]. Nitrates above a certain level in drinking water may cause serious health problems due to toxicity such as blue baby syndrome, stomach and gastrointestinal cancer, high blood pressure [3]. It has been reported that if the drinking water contains more than 10ppm nitrate- nitrogen, it could affect the health of infants, giving rise to blue babies [4]. Not only due to pollution but also due to the climate change the availability of ground water is further limited. Therefore, the natural water resource should be managed efficiently. One of the methods of managing water efficiently is to recycle waste water, which can reduce the pressure on both the supply and disposal aspects of water management. Disposal of kitchen waste water is a problem in households especially in the urban and suburban areas of Jaffna, where the land area is limited and drainage facilities are improper. In most households kitchen wastewater stagnate and pose risk due to breeding of dengu causing mosquitoes.

Growing plants in kitchen waste water is a possibility to recycle water which can solve problems of wastewater disposal as well as water scarcity. In a five member family more than 20 L kitchen wastewater is discharged. This kitchen wastewater can be recycled by planting leafy vegetables in a simple hydroponics system. Leafy vegetables are excellent sources of carotene, folate, niacin, iron, vitamin C and calcium.These are of special importance in the prevention of avitaminosis A, a major cause of blindness in young children.

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Ipomoea aquatica and *Alternanthera sessilis* are semi aquatic, tropical plants grown as a leafy vegetable. It is possible to grow both these plants in a hydroponics system. Such a system not only recycles the kitchen wastewater but also produce healthy and fresh food source.

Nitrogen, phosphorus and potassium are the major nutrient requirement for plant growth. Nutrient content of Jaffna ground water is nitrate nitrogen range from 0.16mg/L to 17.41 mg/L, chloride 28-734 mg/L, pH 6.9-8.1, EC 0.43dS/m-2.99dS/m [1]. The sole source of water of household use in this area is ground water which is derived from open dug wells in each household. Waste water from kitchen may have varying nutrient content depending on the nutrient content of well as well as washing activities in respective kitchens. Therefore nutrient analysis of wastewater and respective ground water is essential. As the ground water has risk of nitrate pollution in Jaffna peninsula wastewater produced from ground water source also has the same risk. In addition vegetables grown in hydroponics in this wastewater also may have risk level of nitrate hence analysis of plant tissue for nitrate is also important. Therefore an experiment was conducted in the Department of Agricultural Chemistry with the following objectives. The main objective of this study was to study the feasibility of using kitchen wastewater to grow *Ipomoea aquatic and Alternanthera sessilis* in a simple hydroponics system in home gardens of selected households in Jaffna peninsula. The main objective was supported by following sub objectives:

- Analyze the nutrient content (nitrogen, phosphorous, potassium and calcium) and other properties of ground water and kitchen wastewater in selected households.
- Test the growth of each selected plants in wastewater.
- Analyze the nitrate content of the plant tissue grown in waste water

MATERIALS AND METHODS

Study Area: In this study, seven areas were selected to plant leafy vegetables in hydroponic system using kitchen wastewater. Chavakacheri, Kalviyankadu, Nallur, Jaffna town, Thirunelvely, Kokuvil and Kondavil areas were selected. Jaffna town and Nallur were selected as densely populated areas.Thirunelvely and Kondavil were selected as farming area. Other areas were selected to include wells water of variable nutrient availablity. In each area three houses were selected.

Methodology: Kitchen wastewater, except detergents wash water was collected in buckets from the selected households daily. This wastewater include rice and vegetable wash water and other kitchen wastewater. Weight of cuttings in each pots were measured before planting. Kitchen wastewater was used as nutrient media for both plants in a hydroponic system. Three liters of collected wastewater was filtered through plastic stainer. Filterate was used for each pot. In each plant two replicate pots were planted.Totally four pots were planted in each selected household. five cuttings were planted in each pot either *Ipomoea aquatica* or *Alternanthera sessilis*. Wastewater in pots were changed in alternative days. Twenty five (25 ml) of wastewater used to planting was collected for nutrient analysis of the wastewater. This collected wastewater was analyzed for nitrate-N, phosphorous, pottasium, calcium, pH, electrical conductivity in every week in the laboratory. As the source of water is groung water, each household ground water were analyzed for Nitrate-N, phosphours [5], potasium [6], calcium, pH and EC. These plants were harvested after three weeks. Fresh weight of plants of each pot was measured. Plant tissue was analyzed for Nitrate-N [7] after harvesting.

Statistical Analysis: The experimental design was split plot, main plot being different areas and sub plot being individual households. Paired t-test was done to compare ground water and respective waste water. Duncan New Multiple Range Test (DNMRT) was used to compare wastewater and yield of plants from seven different areas.

RESULTS AND DISCUSSION

pH: The pH affects on the availability of nutrients to plants. In hydroponic systems the plant productivity is closely related with nutrient uptake and pH regulation [8]. The average pH of the kitchen wastewater and ground water samples were 7.65 and 7.33 respectively (Table 1). There was significant different in pH between kitchen wastewater and ground water. According to Ayres and Westcot [9] normal pH range for irrigation water is from 6.5 to 8.4. All the kitchen wastewater in selected households was within the range of requirement for irrigation water.

Table 1: Comparison of ground water and respective waste water

Area	Average pH		Average EC(dS/m)		Average nitrate-N (mg/L)		Average P (mg/L)		Average K (mg/L)		Average Ca(mg/L)	
	GW	WW	GW	WW	GW	WW	GW	WW	GW	WW	GW	WW
Kokuvil	7.21	7.66	1.20	1.12	6.76	6.36	0.17	0.95	12.53	7.00	28.40	33.31
Kondavil	7.26	7.40	1.04	0.94	8.67	4.35	0.08	1.52	15.61	12.24	30.37	35.76
Nallur	7.32	7.86	1.37	2.74	3.06	2.58	0.45	1.69	19.34	17.14	26.80	36.33
Kalviyankadu	7.63	7.77	1.43	1.38	4.98	5.73	0.28	1.71	20.22	23.26	27.20	40.29
Thirunelvely	7.36	7.65	1.71	1.45	5.60	3.66	0.22	2.12	12.42	9.10	44.00	38.04
Jaffna town	7.38	7.61	1.48	1.37	5.40	2.84	0.16	2.03	21.76	21.84	33.60	40.00
Chavakacheri	7.18	7.52	1.35	1.29	0.98	3.04	0.28	2.31	13.96	7.84	25.60	27.96
Average	7.33	7.65	1.36	1.47	5.07	4.08	0.24	1.71	16.55	13.89	30.85	35.96
Paired t- test p	0.001 significant		0.5659 Not significant		0.2437 Not significant		0.0001 Significant		0.0163 Significant		0.0162 Significant	

GW= Ground water

WW= Wastewater

Growth of *Ipomoea aquatica*

Electrical Conductivity: Average EC in the kitchen wastewater and ground water were 1.47 and 1.36 dS/m, respectively (Table 1). The EC in the wastewater was significantly higher than the ground water. There was no statistically significant different in EC between kitchen wastewater and ground water. Department of Agriculture was recommended the ideal EC range for hydroponics from 1.5 to 2.5dS/m. Higher EC prevents nutrient absorption due to osmotic pressure and lower EC severely affect plant health and yield. In Nallur 1 and Nallur 2 households EC level was higher than 2.5dS/m.

Nitrate Nitrogen: The average nitrate nitrogen in kitchen wastewater and ground water were 4.08 and 5.07 mg/L, respectively (Table 1). The World Health Organization has adopted a 10 ppm nitrate-N as maximum standard for safe drinking water. Nitrate nitrogen in wastewater was not significantly differing from the ground water. Nitrate nitrogen in kitchen wastewater was highest in Kondavil households and lowest in Thirunelvely households. Nitrate content of waste water of Kokuvil and Kondavil household were significantly higher than Thirunelvely and Chavakacheri households. There was no significant difference among Kokuvil, Kondavil and Kalviyankadu household nitrate levels and also among Kokuvil, Nallur, Kalviyankadu and Jaffna town households. Figure 1 show the Nitrate N in kitchen wastewater of different areas.

Phosphorous: Average phosphorous in the kitchen wastewater and ground water were 1.71 and 0.24 mg/L, respectively (Table 1). There was significance different of phosphorous in kitchen wastewater and ground water. Phosphorous in kitchen wastewater was highest in Chavakacheri and lowest in Kokuvil area. There was no significant difference in phosphorous between the selected areas. Fig. 2 shows the phosphorous of kitchen wastewater in selected areas.

Potassium: The average potassium in the kitchen wastewater and ground water were 13.89 and 16.55 mg/L, respectively (Table 1). Potassium level was significant different between kitchen wastewater and ground water. Fig. 3 shows the potassium in kitchen wastewater in selected areas. Potassium in kitchen wastewater was highest in Kalviyankadu and lowest in Kokuvil area. There was no significance difference in potassium in Chavakacheri, Thirunelvely, Kondavil and Kokuvil area. Jaffna town and Kalviyankadu had significantly higher potassium than Kokuvil, Thirunelvely and Chavakacheri areas.

Calcium: Average calcium in kitchen wastewater and ground water were 35.96 and 30.85 mg/L respectively (Table). There was significance different in calcium between kitchen wastewater and ground water. Fig. 4 shows the calcium in kitchen wastewater in selected studied areas. Calcium in kitchen wastewater was highest in Jaffna town and Kalviyankadu area and lowest in Chavakacheri area. Calcium level in Chavakacheri area was significantly lower than Kondavil, Nallur, Kalviyankadu, Thirunelvely and Jaffna town areas. Calcium was negatively correlated to plant growth. Table 1 shows the results of Pearson correlation between calcium in kitchen wastewater and other nutrients in kitchen wastewater.

Average growth range was from 3.12 g to 39.58 g. Fig. 5 shows the growth of *Ipomoea aquatica* in selected areas. *Ipomoea aquatica* showed highest growth in kitchen wastewater in Chavakacheri area and lowest in

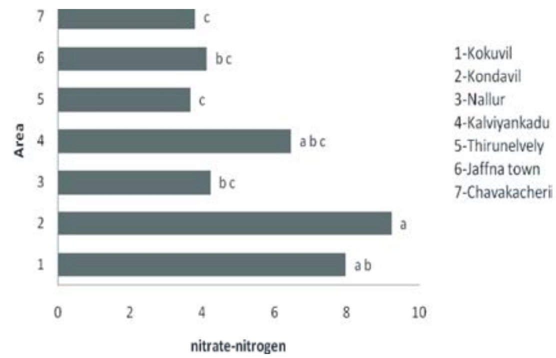

Fig. 1: Nitrate N in kitchen wastewater in selected areas

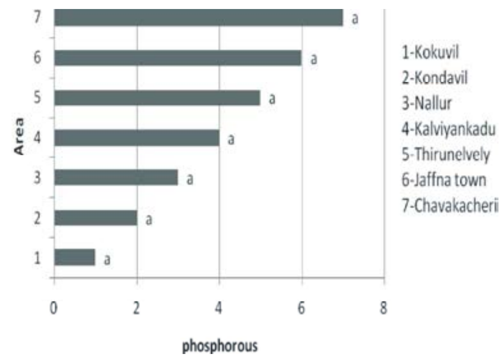

Fig. 2: Phosphorous in kitchen wastewater in selected areas

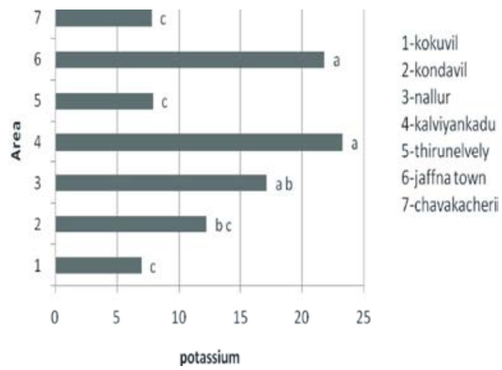

Fig. 3: Potassium in kitchen wastewater in selected areas

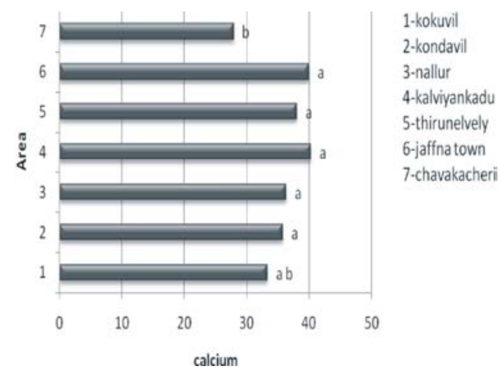

Fig. 4: Calcium in kitchen wastewater in selected areas.

Means with similar letters are not significantly different by Duncan's grouping at p=0.05

Jaffna town. There was no significant difference observed in growth of *Ipomoea aquatica* among Thirunelvely, Kalviyankadu, Nallur, Kondavil and Kokuvil area. Calcium in kitchen wastewater was negatively correlated with *Ipomoea aquatica* growth (Table: 2). Calcium was also negatively correlated with phosphorous in kitchen wastewater and also calcium was low in Chavakacheri area. It may one of the reasons for the best performance of *Ipomoea aquatica* in Chavakacheri.

Nutrients in Plant Tissue of *Ipomoea aquatica*

Nitrate-Nitrogen: Nitrate N in plant tissue of *Ipomoea aquatica* was highest in Kalviyankadu area and lowest in Chavakacheri area. There was no significance difference of nitrate N in *Ipomoea aquatica* plant tissue in areas of Jaffna town, Thirunelvely, Kalviyankadu, Nallur, Kokuvil and Kondavil households. Higher nitrate N in plant tissue was observed with increasing nitrate content of water in Ipomoea aquatica grown hydroponically in a previous study [10]. However, in that study [10] except for nitrate levels all other nutrients were kept constant. Hence in the present study effect of nitrate in water in plant tissue would have been masked by the effect of other nutrients which is variable. Nitrate N in *Ipomoea aquatic*a plant tissue was ranged from 15.78 to 26.31mg/Kg. Joint FAO/WHO Expert Committee on Food Additives (JECFA, 2002) has established an Acceptable Daily Intake of nitrate N as 3.7mg/Kg body weight /day. According to ADI limit a 6 month baby (7-8Kg), 1 year child (9-11 Kg) and an adult (50-60 Kg) may ingest 26-30 mg nitrate N/day, 33-40 mg nitrate N/day,180-225 mg nitrate N/day without harmful effects.

The highest level of nitrate N was observed in *Ipomoea aquatica* (26.310mg/Kg). Assuming a maximum daily intake of 100g leafy vegetable by human, the nitrate intake will be a (26.31mg/Kg) maximum of 2.63 mg nitrate N. This amount is suitable to consume without harmful effects even to a 6 month baby. Fig. 6 shows the nitrate N in *Ipomoea aquatic* plant tissue.

Growth of Alternanthera Sessilis: *Alternanthera sessilis* showed highest growth in kitchen wastewater in Chavakacheri and lowest in Kalviyankadu area. There was no significance difference in growth of *Alternanthera sessilis* in kitchen wastewater among Chavakacheri, Jaffna town, Thirunelvely, Nallur, Kondavil and kokuvil areas and also among Jaffna town, Thirunelvely, Kalviyankadu, Nallur, Kondavil and Kokuvil areas.

Table 2: Results of Pearson correlation between calcium in kitchen wastewater and other nutrients in kitchen wastewater

Nutrient	P	K	N	S	Ca	pH	EC	*Ipomoea aquatica*	*Alternanthera sessilis*
Calcium Pearson correlation	-0.13	0.36	0.66*	0.44*	1	-0.11	0.36	-0.28	-0.48*

.*-correlation is significant at the 0.05 level (two-tailed)

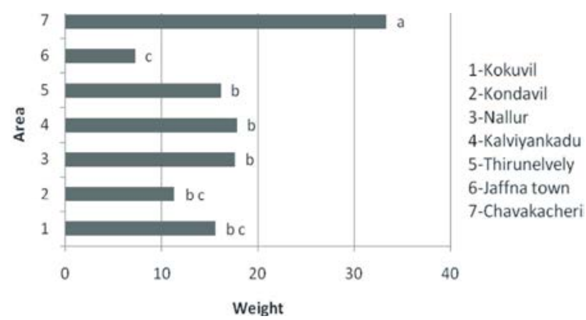

Fig. 5: Growth of *Ipomoea aquatica* in kitchen wastewater.
Means with similar letters are not significantly different by Duncan's grouping at p=0.05.

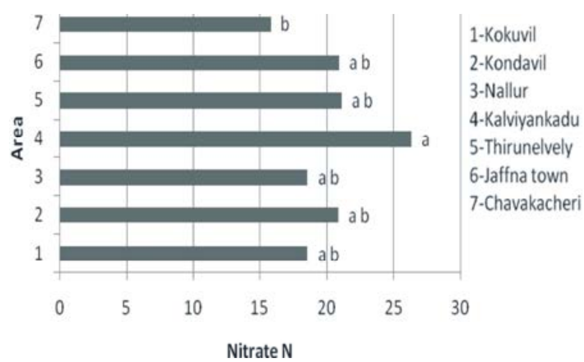

Fig. 6: Nitrate N in *Ipomoea aquatica* plant tissue.
Means with similar letters are not significantly different by Duncan's grouping at p=0.05

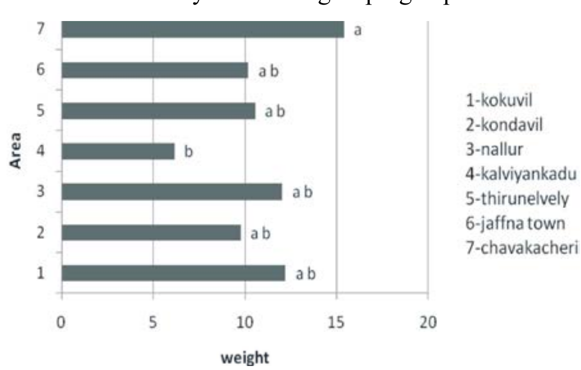

Fig. 7: Growth of *Alternanthera sessilis* in kitchen wastewater.

According to Table 2 calcium in kitchen wastewater was significantly negatively correlated with *Alternanthera sessilis* growth and also calcium was also negatively correlated with phosphorous in kitchen wastewater.

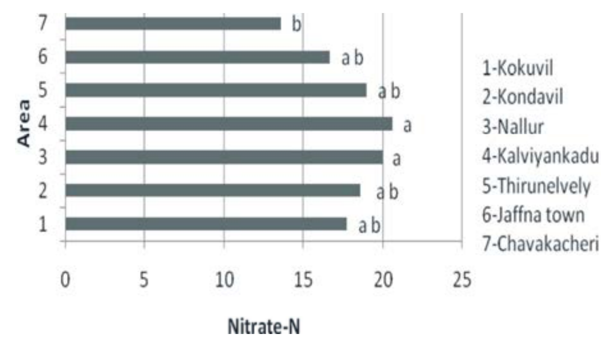

Fig. 8: Nitrate N in *Alternanthera sessilis* plant tissue

Calcium was low in Chavakacheri area. It may be one of the reasons for better growth of *Alternanthera sessilis in* Chavakacheri area. Fig. 7 illustrates growth of *Alternanthera sessilis* in kitchen wastewater.

Nitrate N in Alternanthera Sessilis: Nitrate N in *Alternanthera sessilis* plant tissue was ranged from 13.56 to 20.58 mg/Kg. Nitrate N in *Ipomoea aquatic*a plant tissue was ranged from 15.78 to 26.31 mg/Kg. Joint FAO/WHO Expert Committee on Food Additives [11] has established an Acceptable Daily Intake of nitrate N as 3.7mg/Kg body weight /day. According to ADI limit a 6 month baby (7-8Kg), 1 year child (9-11 Kg) and an adult (50-60 Kg) may ingest 26-30mg nitrate N/day, 33-40mg nitrate N/day,180-225mg nitrate N/day without harmful effects. Fig. 8 illustrates nitrate N in *Alternanthera sessilis* plant tissue

CONCLUSION

Phosphorous, potassium, calcium and pH and were significantly different between kitchen wastewater and the respective ground water. Nitrate N and EC were not significantly different between kitchen wastewater and the respective ground water. *Ipomoea aquatica* and *Alternanthera sessilis* were grown better in kitchen wastewater hydroponic system in Chavakacheri area than Kokuvil, Kondavil, Nallur, Kalviyankadu, Thirunelvely and Jaffna town area. Calcium was lower in Chavakacheri than other area. There was negative correlation between calcium level and plant growth. It was one of the reasons for better growth showed in Chavakacheri area. Nitrate nitrogen content of both plant tissues showed safe levels for consumption. Study therefore indicates the potential to hydroponically grow *Ipomoea aquatica* and *Alternanthera sessilis* using kitchen wastewater in household level, which is a good technique to reuse of kitchen wastewater and fulfill the family demand of leafy vegetables. Similar approaches could be used in other areas or countries where ground water is used by households for cooking and drinking.

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