A Study on Effect of Kitchen Wastewater Irrigation on Quality of Soil and Crop Growth

Rajkumar Pandurang More[1], Dr. Sunil Bhimrao Thakare[2]

[1]Civil Environmental Engineering Department, ABMSP's APCOER Parvati, Pune, MH, India
[2]Principal and Professor, Civil Environmental Engineering Department, ABMSP's APCOER Parvati, Pune, MH, India

Abstract: ***Roof Gardens, Backyard Gardens, Allotment Gardens, Community Gardens and Road side Gardens were part of green development in urban areas. The present irrigation facilities for these gardening are fulfilled by potable water from water treatment plants. The demand of water for irrigation of urban gardens is increasing day by day. Around 60% of total water used in kitchen was converted in the form of wastewater. The biodegradable organic constituents present are around 80% in kitchen wastewater. In the present practices highly concentrated kitchen wastewater is disposed off in municipal sewers or inland water bodies or on land directly. These practices are preliminarily responsible for pollution of ambient atmosphere. Also the plant nutrients present in kitchen wastewater are wasted. The objective of this study is to recycle the SBR treated centralized kitchen wastewater for Urban Irrigation. The research study includes a comparative study to determine quality of soil irrigated with Potable Water (PW), Treated Kitchen Waste Water (TKW) and Untreated Kitchen Wastewater (UKW). During this work growth of plants also observed with respect to quality of water used for irrigation.***

Keywords: Urban Gardening, Irrigation, Kitchen Wastewater, Plant Nutrients, Soil Quality

1. Introduction

The demand of water for irrigation of urban gardens is increasing day by day. This may consume fresh water from water resources. On other side of urbanization to satisfy the basic need of crowded population various service providing sectors are developing rapidly. Centralized kitchens, Hotels, Restaurants are the examples of food supply service providers to satisfy basic need of urban population. The quantity of water required in kitchens and after process wastewater generation from various kitchen activities is remarkable. Around 60% of total water used in kitchen was converted in in the form of wastewater. The biodegradable organic constituents present are around 80% in kitchen wastewater. In the present practices highly concentrated kitchen wastewater is disposed off in municipal sewers or inland water bodies or on land directly. These practices are preliminarily responsible for pollution of ambient atmosphere. Also the plant nutrients present in kitchen wastewater are wasted. As demand of water for urban irrigation increasing day by day along with problems due to direct disposal of kitchen wastewater, the objective of this study is to recycle the SBR treated centralized kitchen wastewater for Urban Irrigation. The research study includes a comparative study to determine quality of soil irrigated with Potable Water (PW), Treated Kitchen Waste Water (TKW) and Untreated Kitchen Wastewater (UKW). During this work growth of plants also observed with respect to quality of water used for irrigation.

Kurian et al. reviewed that untreated domestic wastewater contaminates the rivers, which is a major source of drinking water. The case study of Godavari river basin at Karimnagar demonstrates that the strong relations between wastewater generated during high rainfall months and storm drain overflows. Also the public health is affected due to climate variability in the slum populations of Karimagar town. The water quality in river also affects badly on periurban agriculture and village areas. An important finding of this is in relates with the economics of wastewater reuse. The findings of this study are the recycling of wastewater may promote double crops increasing returns by six times and reduced expenses on chemical fertilizers [20]. Albalawneh & Chang studied grey water characteristics and various treatment technologies to treat gray water. The aim of this study is design of greywater recycling system for restricted agricultural irrigation reuse. The study shows quantity of greywater generated in household is varies from 50% to 80%. The researchers suggest the possible greywater recycling scheme for agricultural irrigation reuse purposes through this study [03]. As per the Metcalf and Eddy all types of grey waters have good biodegradability in terms of COD (chemical oxygen demand): BOD5 ratio. Compared to the suggested COD: N:P ratio (N = Nitrogen; P = Phosphorous) of 100:20:1 for domestic wastewater [26]. Shastri and Raval studied waste water management in India conditions. The study focuses the views common man and mainly from the stakeholders who suffer due to uncontrolled and haphazard due to discharge of waste into the natural water bodies. The study shows statistical variation India, which shows 25-30% waste water, is treated up to the satisfactory level. The study of Pune city shows that the developed master plan by Pune Municipal Corporation for collecting and treating 100% of the sewage likely to be generated by 2015, but practically it seems to be impossible, taking into consideration the present haphazard and unplanned growth of the city [30]. Vigneswaran & Sundaravadivel discussed about reuse of wastewater for domestic and agricultural purposes. The focus of this study is on reuse of wastewater for water-demanding activities so that as per as possible limited freshwater resources are consumed. The review of all the case studies presented in this paper point towards the resuse of wastewater has to serve as a viable potential alternative source of water, in future [31]. Jayyousi studied grey water reuse in arid regions a step towards sustainable water management. The study also discussed about effective use of gray water in groundwater recharge, landscaping, and plant growth. The study concluded that the aim of current environmental policies should be control pollution with promote maximum recycling and reuse of GW within households and communities [05]. Huelgas et al. carried out a comparative study among a) kitchen-sink wastewater only, and b) a mixture of kitchen-sink wastewater and washing-machine wastewater treatment by using a submerged membrane bioreactor. The problem of foaming observed due to the mixture of kitchen-sink wastewater and washing-machine wastewater. The study concludes that the washing-machine wastewater has some components, which are not easily biodegradable [15].

2. Methodology

Figure 1 is the flow chart of the normal sequence steps of the research approach which is followed in this research work.

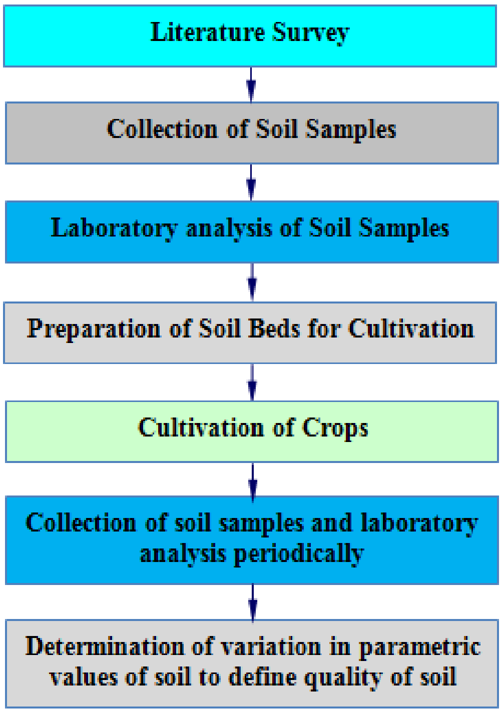

Figure 1: A Flow diagram of Research Approach

2.1 Collection of Soil Samples

The soil Samples were collected from agricultural land surrounding to Charoli Budruk, Pune. Samples are collected at mid day time i.e. at 1.30 pm. Figure 2 shows soil sampling from field.

Figure 2: Sampling of Soil with Core cutter from field

2.2 Experimental work

Cultivation of Crops

Laboratory analysis of Soil Samples

All collected soil sample from field is tested at Environmental Engineering Laboratory of Sant Tukaram Polytechnic, Pune. The parametric values of soil quality were as per Table 1.

Table 1: The parametric values of quality of soil sample

No.	Parameters	Value
1	pH	8.34
2	EC dS/m	0.59
3	Porosity %	61.45
4	N (Nitrogen) Kg/ha	18.47
5	P (Phosphorus) Kg/ha	12.32
6	K (Potash) Kg/ha	149.78

Preparation of Soil Beds for crop cultivation

For cultivation of crops three wooden box having size (3 * 2 * 1) feet were developed. To remove excess water the perforations were provided at the bottom of the box. A layer of soil sample collected from field was loaded in three different boxes for building a soil bed of uniform 6" thickness.

The crop cultivation and observation during crop yield

Fenugreek and Spinach crops were taken one after another in sequence for the period of 25 days and 50 days respectively. Three different soil beds were used for comparative status. The quality of water used for irrigated were used to analyze Potable Water (PW), Treated Kitchen Wastewater (TKW) and Untreated Kitchen Wastewater (UKW). The soil samples were collected for laboratory analysis from each tray separately at the interval of seven days (see Figure 3).

Figure 3: Collection of soil samples from study soil beds

3. Results and Discussions

The results of parametric values considered to define soil quality were Porosity (%) as shown in Table 2.

Table 2: The percentage porosity values of soil irrigated by PW, TKW and UKW

Days	S in %	PW in %	TKW in %	UKW in %
1	61.45	61.45	61.45	61.45
7	61.45	61.39	59.63	52.02
13	61.45	59.49	57.70	50.88
19	61.45	58.51	55.56	50.62
25	61.45	58.31	55.55	50.49
31	61.45	57.67	55.33	49.87
37	61.45	57.44	55.18	48.85
43	61.45	56.44	55.12	48.52
49	61.45	56.30	54.68	47.43
55	61.45	56.07	54.19	46.04
61	61.45	55.08	53.96	44.95
67	61.45	54.33	52.37	43.50
75	61.45	54.22	52.16	42.10

Note: S – Soil; PW – Potable Water; TKW – Treated Kitchen wastewater and UKW – Untreated Kitchen Wastewater

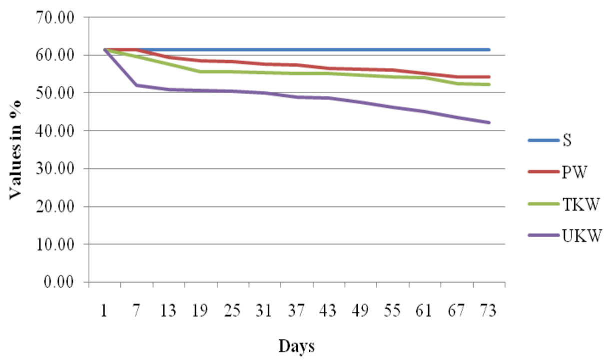

Figure 4: A graphical representation of variation in porosity of soil (by PW, TKW and UKW)

From Table 2 & Figure 4 it is observed that

- The observed value of % porosity of soil irrigated by untreated kitchen wastewater is (42.10) lowest as compared with Soil irrigated by potable water (54.22) highest and treated kitchen wastewater (52.16) moderate at the end of 75th day of study.
- It shows that irrigation by untreated kitchen wastewater rapidly reduces porosity of soil as compared with potable water and treated kitchen wastewater.

The crop growth and observation during crop yield

Figure 5: Growth of Fenugreek crop at 25th day of yield

From Figure 5 the observed growth of Fenugreek crop in first box irrigated with treated kitchen wastewater is 213 mm, second box irrigated with potable water is 205 mm and third box irrigated with untreated kitchen wastewater is 165 mm.

- The observed growth of Fenugreek crop irrigated with treated kitchen wastewater is highest, moderate growth observed for potable water and worst growth observed for untreated kitchen wastewater.
- The observed growth of roots penetrate inside soil bed were highest for potable water, lowest for untreated water and moderate for treated kitchen wastewater.

Figure 6: Growth of Spinach crop at 30th day of yield

From Figure 6 the observed growth of Spinach crop in first box irrigated with treated kitchen wastewater is 163 mm, second box irrigated with potable water is 145 mm and third box irrigated with untreated kitchen wastewater is 110 mm.

- The observed growth of Spinach crop irrigated with treated kitchen wastewater is highest, moderate growth observed for potable water and worst growth observed for untreated kitchen wastewater.

4. Conclusions

The work carried out under this research project were the application of treated and untreated kitchen waste water for irrigation, determination of variation of soil quality with reference to quality of water used for irrigation and effect of quality of water on growth rate of crops.

The following are the conclusions of this study;

1. The observed variation in parametric values of quality of soil irrigated by potable water and treated kitchen wastewater are approximately identical.
2. The quality of soil irrigated with untreated kitchen wastewater badly affected in terms of porosity, salinity and crop fertility.
3. The crop growth in soil bed irrigated with treated kitchen wastewater is good as availability of appropriate porosity and plant nutrients.
4. The fresh water utilized for irrigation has replaced by recycled kitchen wastewater, which conserves natural water resources.

References

[1] Albalawneh, A. and Chang,TK., “REVIEW OF THE GREYWATER AND PROPOSED GREYWATER RECYCLING SCHEME FOR AGRICULTURAL IRRIGATION REUSES” International Journal of Research – Granthaalayah, Vol. 3, No. 12, pp. 16-35, 2015.

[2] Al-Jayyousi, Odeh R., "Greywater reuse: towards sustainable water management." Desalination, Vol. 156, No. 1-3, pp. 181-192, 2003.

[3] Huelgas, A., Nakajima, M., Nagata, H., & Funamizu, N., “Comparison between treatment of kitchen sink wastewater and a mixture of kitchen sink and washing machine wastewaters.” Environmental technology, Vol. 30, Issue 1, pp. 111-117, 2009.

[4] Kurian, M., Reddy, V. R., Dietz, T., & Brdjanovic, D., “Wastewater re-use for peri-urban agriculture: a viable option for adaptive water management?.” Sustainability science, Vol. 8, No. 1, pp. 47-59, 2013.

[5] Metcalf & Eddy, Wastewater Engineering Treatment and Reuse, McGraw-Hill Education (India) Private Limited, New Delhi, 2004.

[6] Shastri, SS. and Raval, P. M., "RECYCLE AND REUSE OF TREATED SEWAGE WITHIN POLLUTER’S BOUNDARY FOR SUSTAINABLE WASTEWATER MANAGEMENT: A CASE STUDY, PUNE, INDIA." Journal of Environmental Research and Development, Vol.7, No. 1A, pp. 245-256, 2012.

[7] Vigneswaran, S., & Sundaravadivel, M., Recycle and reuse of domestic wastewater. Saravanamuthu (Vigi) Vigneswaran], in Encyclopedia of Life Support Systems (EOLSS), Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford, UK,[http://www. eolss. net], 2004

Author Profile

Rajkumar Pandurang More obtained BE Civil and pursuing M.E. degree from the Civil Environmental Engineering Department, ABMSP’s APCOER Parvati, affiliated to Savitribai Phule Pune University, Pune, MH, INDIA. His area of specialization is Environmental Engineering. He has Published 03 research papers in International Journals & 03 papers in national conferences. He has more than 26 year’s industrial and institutional experience.

Dr. S. B. Thakare obtained PG and doctoral degrees from Sant Gadgebaba Amravati University. His area of specialization is Environmental Engineering. He has Published 20 research papers in International Journals & 15 papers in international conferences. He has awarded as best lecture award by Indian water works association in – 42nd Annual Convention of Jodhpur on 29th Jan. 2010.