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EFFECTIVENESS OF ECOLOGICAL SANITATION FROM THE VIEWPOINT OF URINE APPLICATION ON VEGETABLES IN CENTRAL NEPAL

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Abstract

Ecological sanitation can be defined as water conserving and nutrient recycling system for use of human urine and excreta in agriculture. In Nepal, every year 180 thousand ton of chemical fertilizer were imported. Ecological sanitation would count a lot to utilize locally available resources, to regenerate soil fertility, and to save national currency. The study was carried out at District, Nepal from March – August, 2016 to test the efficacy of human urine for improving crop performance and to estimate the feasibility of ecological sanitation. Five eco-san toilets were constructed and questionnaire survey was done. Villagers were asked about socio-economic parameters, farming practices, awareness of ecological sanitation and fertilizer value of urine. Eighty three percent respondents were engaged in agriculture growing mainly vegetables, which may raise the feasibility of ecological sanitation. Their concern on water deficiency in dry season, high demand of chemical fertilizer, sanitation awareness need to be solved. In the field experiment, cauliflower was cultivated to

compare the fertilizer value of urine with chemical fertilizer and no fertilizer with three replications. Urine fertilized plots produced similar yields compared to those with chemical fertilizer and higher yields than those without fertilizer. To be able to generalize this conclusion, it is important to conduct experiments with different seasonal crops.

Keywords

Agriculture, Chemical fertilizer, Ecological sanitation, Yield

1. INTRODUCTION

The current world population of 7.3 billion is expected to reach 8.5 billion by 2030 (UN, 2016). Water scarcity, poor water quality and inadequate sanitation negatively impact on food security, livelihood choices and educational opportunities for poor families across the world (UN, 2015). At least 1.8 billion people globally use a source of drinking water that is focally contaminated, 2.4 billion people lack access to basic sanitation services such as toilets or latrines (UN, 2015). The world spends the required amount of money on sanitation but inappropriately, there is need for appropriate technologies to achieve universal access (Mara, Lane, Scott, & Trouba, 2010). The effective sanitation technology should both provide access and reduce public health risks.

Ecological sanitation (Ecosan) is one type of sanitation option where the contents of latrine (manure) or urine diverted or both are used as fertilizers for agricultural purpose. It is also defined as a system that prevents diseases and promotes health; protects the environment and conserves water; recovers and recycles nutrients and organic matter to soil (Esrey, 2001). Ecosan differs from other decentralized sanitation system (such as a pit latrine) as there is a deliberate focus on the reuse of excreted material as opposed to treating it as waste (Langergraber & Muellegger, 2005). It is important to note that ecosan is not a single new technology, but an approach which takes economic, ecologic and social parameters into account by promoting new sanitation principles and concepts. The ecosan process can be thought of as a "closed loop" cycle of nutrient flow (Figure 1). The cycle starts with human consumption of harvested food, which then leads to defecation and urination. This excretion of bodily waste is regarded as a resource by an ecosan technology (Esrey, 2001).

Closing loop agriculture has direct benefits for biodiversity also, within the soil itself, in the aquatic environment and within the context of climate change (Biodiversity Work Package, 2015). Ecosan promotes recycling of nutrients contained in excreta to grow crops and fruits; thus enhancing food security and reducing the need to rely on agriculture fertilizers (Schuen & Parkinson, 2009).

Human excreta contain nutrients suitable for agriculture such as nitrogen, urea, potassium and phosphorus (Jönsson, 2004).

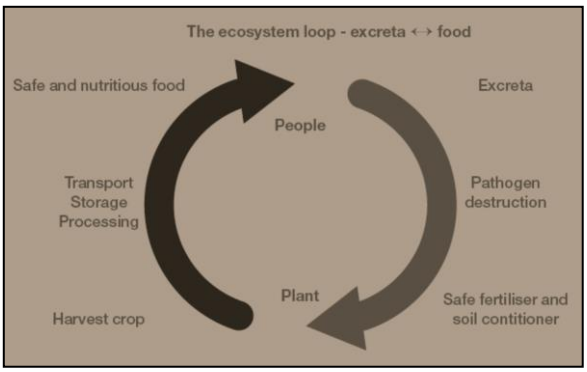


Figure 1: *The Closed loop of Ecological Sanitation*

Human urine is a liquid waste product of the human body secreted by the kidneys by a process of filtration from blood called urination and excreted through the urethra. Each individual produces 1-1.5 l of urine per day in 4-5 times and an adult person excretes on average of 500 l urine per year (Jönsson, 2004). Children urinates about half of that of the adults amount. It is estimated that 550 l of urine contains 4 kg of nitrogen, 365 g of phosphorus and 1 kg of potash (Jönsson, 2004). However, the composition of human urine varies from person to person and from region to region depending upon his/her feeding habit, the amount of drinking water consumed physical activities, body size and environmental factors (Jönsson, 2004). Most of the nitrogen fractions in urine are taken up by plant and which is same as that of the urea or ammonium fertilizer with nitrogen efficiency approximately 90% of that of mineral fertilizer (Jonsson et al., 2005). Loss of nitrogen during storage can be minimized by minimizing temperature and avoiding aeration above the liquid surface in storage tanks (Höglund, 2001).

In Nepal, there is a demand of chemical fertilizer for crop and vegetable production which is mainly imported from the neighboring country India. According to Ministry of Agriculture Development (MOAD, 2011/12), 180140 metric ton (mt) of urea, 65772 mt of diammonium phosphate (DAP) and 2688 mt of potash was sold in 2011/12. The study area is renowned as a basket of vegetable as vegetable such as potato, cauliflower, radish, cabbage, chili is transported to different parts of country and even to India. To minimize the use of chemical fertilizer and to use urine and excreta in agriculture, it is necessary to find out show the benefits in the form of demonstration. The ecosan toilet is new in the area. So, it is also necessary to find out the socio-economic background, people's perception towards ecosan and their acceptance and eagerness to build ecosan toilet.

The objectives of study were set as follows;

- To study the socio-economic status of people including the awareness about ecosan manure
- To assess the effect of urine on crop yield

2. DATA AND METHODS

2.1 Study area

The study was conducted in Palung Village Development Committee (VDC), Makawanpur district in central Nepal from March - August 2016. The area lies at an altitude of 2200 m above sea level with coordinates 27.65°N and 85.07°E. The maximum and minimum annual temperature is 22°C and 0.9°C respectively. The total population in the study area is 5603 (CBS, 2011)

2.2 Questionnaire survey

The questionnaire survey was conducted for 180 households in the study area. At first, the questionnaire survey was done for 120 households before constructing ecosan toilet to understand the awareness level of people regarding such system and to analyze the livelihood situation of people living there. After constructing eco-san toilet, questionnaire survey was conducted for 60 households to understand their perception about this system.

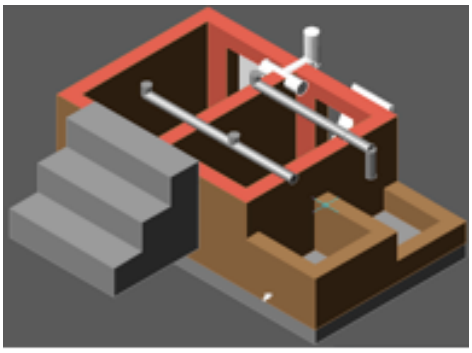
2.3 Construction of ecosan toilet

In the study area, Double Vault Urine Diversion Dry Toilet (DVUT) is constructed for five households. The households were selected after discussing with the village in charge depending upon necessity, occupation, and eagerness to use urine and human excreta in field.

The DVUT has two separate watertight chambers of mason or concrete for storage of faeces, connected with urine collection vessel and collection for anal cleansing water (Figure 2 a) (WaterAid, 2011). The size of each chamber is ca. 0.35 cubic meters and the inner wall is plastered with cement (as referred by (ENPHO, 2007). The chamber is assumed to be filled in six months by a household with a family member of 5-6. Once a chamber is filled, it should be covered well and the next chamber is used for defecation. The faeces are ready to be use as a fertilizer in another six months (Jönsson, 2004, ENPHO, 2007). The vault doors are about 6'×6' to allow easy removal of dry excreta after composting (as referred by WaterAid, 2011). No water is used for flushing and faeces are composted in vaults with addition of ash. Ash is used as cover after defecation so as to increase pH (Pradhan, Piya, & Heinonen-Tanski 2010). and to make it moisture free. A 100 liter plastic barrel is used to collect urine. During this research, the urine is stored for 10 days before using it in field. The cost of one toilet

reached US$550. The cost could be reduced if locally available resources could be used effectively. The demonstration (constructed eco-san toilet) will help to make the people aware about the benefits of eco-san toilet in sanitation and agriculture.

a)



b)

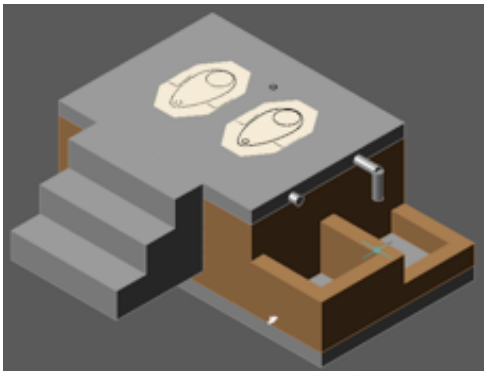


Figure 2: Design Layout for Double Vault Urine Diverting Toilet

2.4 Cultivation experiment

The cultivation experiment was conducted in the farmer's field to find out the effects of urine in production. In total, 380 cauliflowers were planted in 76.5 m^2 area three different treatments (controlled, urine plot and chemical fertilizer plot). The chemical fertilizer was applied in the field according to the farmers' practice (nitrogen 9.01 g/m^2 and phosphorus 3.6 g/m^2). The urine applied was 1.24 l/m2 with urine water ratio 1:3. The urine needed was calculated assuming that 550 l of urine contains 4 kg of nitrogen [8].

The cauliflowers were harvested in one month and were chopped into small pieces, sun dried, oven dried and then weighted to get above ground biomass.

2.5 Soil sampling

The soil samples were taken before starting cultivation experiment from 0-15 cm depth. In each plot, soil was taken from 5 points to make a composite. The soil samples were then air dried, sieved and packed in a plastic bag (considering no air enters the plastic bag) and brought back. Before analyzing in the laboratory of Soil Science, Kyoto University, the sample was transferred into the plastic bottle and used as necessary. The data analyzed from the soil samples showed the basic characteristics of soil in the study area.

2.6 Data analysis

The data obtained from the field and from laboratory was analyzed statistically using ANOVA, Post hoc test to reach a specific conclusion.

3 RESULTS AND DISCUSSION

3.1 Result from questionnaire survey

The questionnaire survey was conducted twice in the study area, before and after constructing ecosan toilet. From the questionnaire survey, it was known that agriculture is the major occupation in the study area. In total 83% respondents were totally dependent upon agriculture but the average land holding size of 50 % household ranges from 0.2-0.3 hectare (ha). According to the respondents, in average 60 kg urea, 48 kg DAP, 1.8 kg potash is used in 0.1 ha land in one year. The main purpose of chemical fertilizer is to boost up production. But due to untimely and uneven distribution of fertilizer and high price, farmers are suffering from low production than they need. Similarly, in the study area, the drainage facility is very poor. It is necessary to find out an alternative option to increase sanitation facility. In both circumstances, ecosan toilet would play an important role to minimize the use of chemical fertilizer for better production and to manage sanitation. Firewood is used in almost every house for their household activities including cooking food, preparing meal for cattle's. Ash can be easily obtained to use in ecosan toilet after defecation.

The survey done after the construction of ecosan toilet showed the willingness of respondents to install ecosan toilet in their house. Before ecosan toilet was constructed in the study area, no any respondents were found who had seen ecosan toilet and were aware about the function and benefits of ecosan toilet. But due to the construction of ecosan toilet in the area, the villagers are found with interest towards the system and were also known about its benefits in agriculture. The positive impact of ecosan toilet in sanitation and production helped to attract people towards such system.

3.2 Result from soil analysis

The soil samples were analyzed to understand some physico-chemical properties of soil (Table 3.1). The soil texture of both sites was found different. The site, Angare had a soil with sandy loam texture having higher percentage of sand (0.05-2.00 mm) whereas Bhot Khoriya had loam soil comprising higher percentage of silt (0.05-0.002 mm). The clay content in Bhot Khoriya is also higher than that of Angare. Although the soil of both sites is acidic, the soil of Bhot Khoriya is more acidic than that of Angare and had more cation exchange capacity (CEC). There is no significant difference in soil among the replications. It showed the uniformity of soil in all replication to reduce the biasness of experiment.

TABLE 3.1: *PHYSICO-CHEMICAL PROPERTIES AND NUTRIENTS CONTENTS IN SOIL SAMPLE*

Village		**Soil Texture (USDA)**			**pH (H_2O)**	**EC (µS/cm)**	**CEC (cmol$_c$/kg)**	**Exchangeable Cations (cmol$_c$/kg)**			
		Sand	Silt	Clay				Na	K	Ca	Mg
		0.05-2.00 mm	0.002-0.05 mm	<0.002 mm							

		%									
Angare	R1	53	39	6.2	5.7	133	9.2	0.05	0.30	5.86	0.88
	R2	57	35	5.7	5.8	85	7.5	0.13	0.38	4.63	0.65
	R3	58	34	6.6	5.6	81	7.6	0.05	0.20	4.29	0.41
Bhot Khoriya	R1	31	50	15	5.2	109	18.6	0.07	0.41	5.03	1.32
	R2	32	51	14	5.3	99	19.0	0.11	0.42	5.04	1.14
	R3	35	48	15	5.0	136	18.3	0.10	0.41	4.82	1.24

3.3 Result from cultivation experiment

The result showed variation in the weight of plant in different treatment (Figure 3). The plant in the urine treatment showed positive impact of urine in growth against the controlled treatment in both field. The plant growth in urine treatment and chemical fertilizer treatment is comparable in both fields (Figure 3). Significant difference was observed between the treatments in village Angare (Figure 3a) and represented the positive effect of urine for the plant growth. But no significant difference was observed between the treatments (Figure 3b) which might be due to the availability of nitrogen in the soil as a residue from the previous fertilizer application. The better growth of cauliflower is seen in the controlled treatment of Bhot Khoriya than of Angare also proves the availability of nutrient in soil.

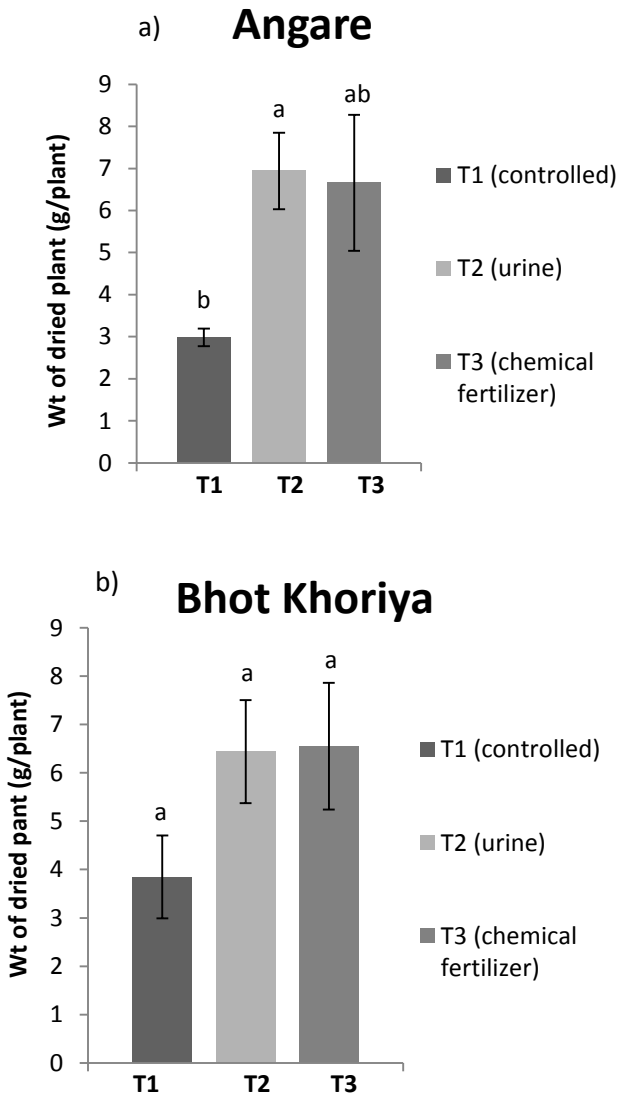


Figure 3: Total Aboveground Plant Biomass in Village Angare (a) and Bhot Khoriya (b).

Significant Differences (P≤0.05) are represented by Lowercase Letters

4. CONCLUSION

The study helped to understand the socio-economic scenario of the study area and the people's livelihood. The study helped to raise the knowledge and awareness of people after introduction of ecosan toilet. It is assumed to increase sanitation facility in the study area due to the utilization of urine and excreta as a fertilizer.

From the cultivation experiment, it was found that there was a difference in the weight of plant biomass among the controlled plot and the plot with urine and also comparable biomass with plot of urine and plot of chemical fertilizer. If the urine collected from the eco-san toilet could replace chemical fertilizer, the money spent in buying chemical fertilizer would be utilized for increasing the livelihood of household member. Further cultivation experiment on use of both urine and excreta is required to evaluate the performance of ecosan manure on agriculture.

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