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Effect of Human Urine as a Fertilizer for Vegetable Growing in Kitemu Zone, Wakiso District, Uganda

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Abstract: *The demand for fertilizer increases with the demand for food as more fertilizer is needed to increase production. This paper assesses the effects, procedures, uses and challenges of human urine as a fertilizer to vegetables growing in Kitemu Zone, Kyengera Town Council (KTC). A case-study design and qualitative and quantitative data collection approaches were used for this paper. Forty five vegetable growers were targeted, of whom 40 were determined using Krejcie and Morgan. Results reveal that human urine is readily available and inexpensive, improves soil and fertility and plant quality, controls and repels pests, increases farmers' incomes and livelihoods and reduces food contamination and chemical fertilizer use. However, the acceptance of using human urine as fertilizer has many limitations, including low consumption rate of water and soft foods, cultural beliefs, inadequate knowledge about the use of human urine, odour, shame, suspicion and environmental conditions. The paper recommends that KTC should sensitize households on the values of human urine, promote gender sensitivity in human urine collection, storage and application, and demonstration centres should offer short-term courses to households on how to use human urine fertilizer.*

Keywords: Food security, sensitization, human urine fertilizer, vegetables growing

1. Introduction

The world's demand for fertilizer has increased throughout the years and is affected by factors such as population growth and economic growth, agricultural production, prices and governance policies (FAO, 2008, as cited in Sene et al., 2013, p.183). This increased demand for fertilizer leads to unstable prices and misuse of resources, for example phosphorus and potassium, which are fixed and non-renewable (Roberts and Stewart, 2002, as cited in Sene et al., 2013, p.182). It is noted that the demand for fertilizers increases with demand for food for ever growing population. Hence, more fertilizers are needed for increased number of products (Pradhan, 2010). Although, whereas human urine can be reused as plant nutrients, too high use of it to vegetables and crops results in accumulation of sodium (Na) and/or nitrogen (N) in soil, which can eventually inhibit plant growth (Sene et al., 2013).

Human urine carries very low levels of pathogens while containing considerable amounts of major plant fertilizing nutrients, such as Nitrogen (N), Phosphorous (P), Potassium (K), Calcium (Ca), Sulphur (S) and Magnesium (Mg). As Ranasinghe et al. (2016, p.280) explain, this implies that the high level of nutrients together with low levels of pathogens makes human urine a potential ingredient for a liquid fertilizer. Human urine as a fertilizer is not only an important means to increase vegetable yields, but necessary to improve products' chemical quality.

This paper examined the use of human urine as a fertilizer for vegetable production in Kitemu Zone, Kyengera Town Council (KTC), Uganda. The emphasis is especially on production procedures, different uses of the fertilizer and the limitations to its adaptation.

2. Literature Review

2.1 Procedures for making human urine as a fertilizer for vegetable growing

As mentioned above, human urine contains significant levels of nitrogen, as well as phosphorous and potassium (Veganic Agriculture Network, 2018). This implies that importing nutrients for gardening are not sustainable

and it is significant to retain our human urine in the local food cycle. Later, it is released out from the body and collected into basins, tins or buckets. Most of the nutrients in the human urine are readily available to the plants. Even though the characteristic smell of ammonia could not be fully eliminated, immediate incorporation into gardens after dilution would be helpful to reduce the smell considerably (Ranasinghe *et al*., 2016). Therefore, human urine is collected and stored in containers from which the legumes and other rotting fresh plants are added into human urine and left to ferment to reduce its toxicity.

It is noted that the guidelines for human urine use are based on its storage time, and temperature, and it should be stored between 2-4 weeks before it is declared safe for plant growth. Further, human urine, as a fertilizer for vegetables, should be stored at least six weeks (Beaune, 2018). During storage, high pH (above 9), temperature and ammonia are the key factors for inactivating pathogens (sswm.info/node). The rise of pH to above 9 occurs naturally and when urea is degraded to ammonium (sswm.info/media). This implies that the pH above 9, phosphate, magnesium, calcium and ammonia are not soluble, but precipitate forming a bottom layer containing phosphor precipitates (struvite), which is handled as fertilizer.

Interestingly, on large scale, collection and storage containers should be sealed to reduce air entering into the storage jerry-cans loss of nutrients (sswm.info/media). Richert *et al.* (2010) add that human urine should be handled in closed tanks and containers and should be spread directly into the soil, not on the plant, in N-doses equivalent to what is recommended for urea and ammonium fertilizers. Fascinatingly, on small scale we note that household members urinate in basins or buckets at night, and in the morning, collected, poured into the storage containers (20 litter jerry-can with clear-cut opening) and covered with a polythene or sack to avoid nutrient loss as well as unregulated dilution. Further, covering reduces the odour from human urine as a fertilizer. Alternatively, facilities and infrastructures can help to collect human urine at semi-centralized locations for distribution and to be transported to agricultural lands (Richert *et al.,* 2010). Regardless, the valuable aspect is a need for nutrients from fertilizer for agriculture, which can be supplied by the stored human urine. When there is no such need, human urine becomes a source of pollution and nuisance.

After the storage period required, human urine is diluted in the ratio of 3:1 water and human urine, which is an effective dilution for vegetables (Pradhan, 2010). However, the dilution can also depend on the nature of soil and type of vegetables. He adds that if diluted. human urine is used in an irrigation system, it is referred to as *fertigation*. This implies that to guarantee the best fertilizing effect and to avoid ammonia losses to air, human urine should be incorporated into the soil as soon as possible. We note that it is better when the human urine as a fertilizer is applied and dry matter or topsoil is added at the point of application. Thus, human urine as a fertilizer can be applied to the crops/vegetables through the following approaches (Pradham, 2010):

> *1) The human urine is introduced in the soils via small ditches besides the young tomato crops. Then the ditches are covered to prevent ammonia loss to the air. 2) Discharged into furrows, with an appropriate distance away from the plants' root base and covered (although this should take place no more than once or twice during the growing season) and 3) Diluted with water in a ratio of 1:2 and applied to plants (two times a week).*

Finally, the human urine as a fertilizer solution is applied to the plants using various equipment such as watering cans and empty water bottles with hole-bottle tops. The human urine as a fertilizer can easily be applied to crops through a ring form at the root-base of the vegetables or through a clear shallow-ring made near the base of the vegetables as this helps to prevent leaf burn by the human urine. It is important to note that after applying the human urine fertilizer, a farmer should cover the vegetables with mulch or cover the shallow-hole with top soil to avoid nutrient loss due to sun rays or rainfall.

2.2. Uses of human urine as a fertilizer for vegetable growing

Optimal application rate of urine depends on nitrogen demand and tolerance of the crop on which it will be used. Nitrogen concentration of the liquid, as well as the rate of ammonia loss during application is put into consideration. Thus, because of its high nitrogen content, human urine should be applied at a rate corresponding to the desired plant nitrogen requirements (Pradhan, 2010; Pradhan *et al.*, 2007). As a general rule of thumb, one can assume that $1m^2$ of cropland can receive 1.5L of human urine per growing season (this quantity corresponds to the daily human urine production of one person and to 40-110 kg N/ha) (Pradhan, 2010).

Stimulatingly, although direct application of human urine fertilizer using a watering can is labour intensive, farmers stressed that it is less demanding compared to the application of other organic fertilizers (Ayuk, 2001). Urine is also a free, locally and constantly available resource as compared to inorganic fertilizers. Being a free resource makes it a highly valuable source of nutrients to support plant growth (Beaune, 2018). Human urine fertilizer is not only a vital means to increase vegetable yields but a way to improve plant chemical-quality. A research by Pradhan reveals that a number of children from developing countries suffer from vitamin-A deficiency which can be avoided by using human urine as a fertilizer for vegetables rich with carotenoids, minerals, vitamins, and other food values to the children (Pradhan *et al.* as cited in Pradhan, 2010, p.19).

Furthermore, human urine is especially beneficial for crops lacking nitrogen or requiring a lot of nitrogen to grow, for example; maize, rice, millet, sorghum, wheat, chard, turnip, carrots, kale, cabbage, lettuce, bananas, paw-paw, and oranges (Beaune, 2018; Upreti, n.d). Therefore, human urine as a fertilizer is ultimate for rural and peri-urban areas where agricultural lands are close to the point of human urine collection, and households can use their own human urine on their own plot of land (Pradhan *et al.,* 2007). Besides, human urine as a fertilizer helps in improving soil environment as it is environmentally-friendly, which eventually supports appropriate plant growth. It is also beneficial for fertilizing peri-urban and urban environments. While not a plant-based technique per se, using own-human urine is a way that vegetable farmers reuse the nutrients obtained from the soil through the food chains, while also diverting their human urine from the water system where it acts as a pollutant. Additionally, human urine was unanimously seen as an excellent crop fertilizer that may also act as a pest deterrent (Sene *et al.,* 2013; Pradhan, 2010; Richert *et al.,* 2010). Based on plant growth and leaf colour, maize plants are healthy, especially where human urine is applied directly (Beaune, 2018) while the occurrence of yellow and tender leaves was observed in the other treatment plots (Andersson, 2014).

Additionally, human urine contains most of the key nutrients and micronutrients which are required in crop production (Kirchmann and Pettersson, 1995). This means that its use is helpful to low nutrient rich soils, especially in the Sub-Saharan Africa (Henao and Baanante, 2006). Farmers' appreciation of human urine as a fertilizer demonstrates the ability of farming practices to enhance soil fertility, and nitrogen is a key factor to influencing their acceptability (Snapp *et al.,* 1998). It is worth noting that even if urine is used on a small scale vegetable production, farmers identify human urine application as an important strategy to increase food security. This helps to increase food production and by contributing to balanced-diet hence, improving access to vegetables. The economic value associated with human urine recycling, through increased incomes from crop sales, was also commonly seen as of great potential (Semalulu *et al.,* 2011). On that note using human urine as fertilizer could 1) increase crop yields, 2) reduce the water and food contamination, 3) reduce the amount of faecal contaminated wastewater and 4) decrease the environmental pollution by reducing energy consumption, as 1.4–1.8 litre of diesel fuel is needed to produce 1 kg N fertilizer and 0.2 litre diesel is needed for the transportation of 1 kg N fertilizer (Bhat *et al.,* as cited in Pradhan, 2010, p.17).

Conversely, human urine is a liquid waste rich in essential plant nutrients such as nitrogen, phosphorous and potassium (Eawag, Gensch & Spuhler, 2018). Although it has been known that human urine could be reused as nutrients for plant, too much application may cause an accumulation of sodium (Na) and/or nitrogen (N) in soil and eventually inhibit plant growth (Sene *et al.,* 2013). Thus, human urine is considered to be a well-balanced nitrogen rich fertilizer and 75 – 90 % of the nitrogen present in the human urine is in the available forms (either urea or ammonium), which becomes ammonium ions in an aqueous solution at neutral pH_1. Phosphorous and potassium present in the human urine are in an inorganic form and are directly available (Ranasinghe *et al.,* 2016).

It is noted that human urine fertilization is valued as a low-cost and low-risk practice, contributing to significant yield increases, suggesting important contributions to food security and income, especially for those who have few options in soil nutrient management (Ranasinghe *et al.,* 2016; Beaune, 2018). Most of the nutrients present in the human urine are readily available for the plants. Even though the characteristic smell of ammonia is not fully eliminated, immediate incorporation into media after dilution would be helpful to reduce the smell considerably (Ranasinghe *et al.,* 2016).

Literature reviewed indicated that human urine carries very low levels of pathogens while containing considerable amounts of major plant fertilizing nutrients: nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), sulphur (S) and magnesium (Mg). Research shows that high level of nutrients together with low levels of pathogens make human urine a potential candidate as a liquid fertilizer which implies that most nutrients present in human urine are readily available for plants. Further, though the characteristic smell of ammonia could not be fully eliminated, immediate incorporation into media after dilution would be helpful to reduce the smell considerably (Ranasinghe *et al.,* 2016).

2.3 Limitations to using human urine as fertilizer for vegetable growing

Storage, transport and spreading are the key issues for use of human urine, especially if it were to be organized on a large scale. It is important to note that the whole system for collection, storage and handling of human urine needs to be constructed to minimize nutrient losses (Kirchmann & Pettersson, 1995). Thus, experiences from handling and storage of animal manure have revealed that nitrogen losses can be as high as 30–77% and phosphorus losses around 4–30%. However, the issues may be quite different in the Third World. Different cultures may not accept the use of human urine as a fertilizer, especially for edible fruits and vegetables, and it may be especially difficult to introduce such a novel idea in many traditional societies (Kirchmann & Pettersson, 1995).

Hygienic concerns have also presented a biasness in the collection, storage and use of human urine as a fertilizer for vegetable growing. Research shows that inadequate knowledge on the use of human urine as a fertilizer poses a challenge to reducing enteric contamination during human urine collection (Pradhan, 2010, p.29). He adds that social norms and cultural perceptions should

be recognized but not treated as absolute barriers to diffusion of the practice. Human urine might not easily be accepted as a fertilizer in many societies, especially if it is applied on edible plants. Many people are suspicious of the quality of the human urine fertilized products. This study tried to address these questions (Pradhan 2010, p.31). The odour of the human urine limits its use by farmers for vegetable growing (Pradhan *et al.,* 2007).

It is worth noting that limited access to tools and equipment important in human urine collection, storage and application to vegetables and other crops have affected the production and use of human urine as a fertilizer in various communities. For example, watering cans and safety gloves hinder the application of human urine fertilizer to vegetables (Eawag *et al.,* 2018). Moreover, although human urine fertilizer results into weed growth, farmers generally agreed that it was a minor problem given the higher vegetable yields. On the other hand, equipment and tools limit collection and storage capacity of human urine and its applicability and practice by farmers (Pradhan *et al.,* 2007). Sene *et al.* (2013) assert that social acceptance limits the use of human urine as a fertilizer. This is because, stored human urine has a strong smell of which neighbouring individuals find it offensive to work with or to have it nearby. However, if human urine is diluted and/or immediately tilled into the earth, its smell can be reduced. Thus, use of human urine may be less accepted in urban or peri-urban areas where household gardens are close to peoples' homes than in rural areas where houses and cropland are far away from the households (Eawag *et al.,* 2018).

3. Methodology

The study employed a case study design using qualitative and quantitative data collection approaches on the procedure for making human urine as fertilizers, the benefits of human urine as fertilizer and the limitations to the use of human urine as a fertilizer in vegetable growing in Kitemu zone, Kyengera Town Council. The study targeted a total of 45 vegetable growers using human urine including male and female practicing backyard agriculture based in Kitemu zone. Therefore, a sample of 40 respondents was determined from 45 vegetable growers using Krejcie and Morgan sample size table. A purposive sampling technique was used to select the respondents practicing backyard agriculture and using human urine as fertilizer to vegetable growing at their households.

Data was collected through primary and secondary sources. The secondary sources included journals, textbooks and academic papers, while primary sources were questionnaires, interviews and observations. Therefore, 40 questionnaires were self-administered to the sampled respondents and collected their responses. However, from these, only 32 questionnaires were found useable for data analysis, giving 80% response rate, which is appropriate to providing reliable information. Content validity index was used to test for validity of the questionnaire (CVI > 0.50 for both experts) and Cronbach alpha coefficient was used to test for reliability (Cronbach alpha >0.60 for all variables). Primary data was analysed using SPSS to generate frequency tables and figures.

4. Results and Discussion

4.1 Procedures for making human urine as fertilizer for vegetable growing

The respondents were asked to provide ranks on the procedures for making human urine as a fertilizer to vegetable growing and their responses were re-arranged and are indicated in Table 1 below

Table 1: Procedures for making human urine as fertilizer

Procedure	Rank (r)
Acquisition of tools and equipment	r1
Locate the storage in a right position	r2
Inform the household members on the values of human urine collection in the night	r3
Collect and store the human urine into storage jerry-cans	r4
Add legume/ rotting plants into the stored human urine in the jerry-can	r5
Store the human urine 2-4 weeks before it is diluted for applicability	r6
Add ash and stir before its application to vegetables	r7
Dilute the human urine with water in the ratio 1:3	r8
Apply the human urine fertilizer (solution) to the vegetables	r9

Results in table 1 above indicates that farmers had to acquire equipment and tools where human urine would be collected (r1). This was followed by location of storage jerry-cans in a right position where every household member and well-wisher would be able to see it and pour the human urine as required (r2). The respondents also noted that provision of information on the values and uses of human urine to vegetable growing for the members to be able to collect the human urine at night through using buckets, tins or basins (r3). Having urinated in the various collectors in night (r4), then human urine in the collectors is taken and poured into storage jerry-cans every morning of each day after waking-up. Thereafter, legume/rotting plants are added into storage jerry-cans (r5) and the human urine was stored for 2-4 weeks period (r6). Further, after the storage period, of two or four weeks, ash is added to the human urine and stirred (r7) for a uniform solution. Thereafter, the human urine is diluted with water in the ratio of 1:3 (r8) and then applied to the vegetables or any other crops (r9) at home deemed necessary for plant growth.

Field findings indicate that farmers who were using human urine as a fertilizer knew the procedures for making it. They clearly indicated that the procedures one follows in making human urine as a fertilizer from the start until it is ready for plant application and common procedures revealed in their order as discussed below:

Acquisition of tools and equipment to collect, store and apply human urine fertilizers to vegetables. These include; jerry-can, buckets, tins and basins. Locating these storage containers in a rightful position where household members and well-wishers would have access and pour the human urine. This implies that household members have to be provided with information required on the values for collecting human urine in the night and its use to vegetable growing. Participants further noted that simple human urine collectors used in the night to collect human urine from the household members in their bedrooms and the collected human urine is poured into the main human urine collection jerry-cans in the morning or any time when someone wakes-up.

One of the respondents noted that,

> *the collection of human urine at the household level was easy and functioned well. It was carried out in various ways for example, some used small buckets and poured the human urine into a bigger storage jerry-cans. The technology was cherished because it facilitated handling of the human urine and kept the storage jerry-can in rightful position* (Respondents B, Kitemu zone, 22/3/2019).

Additionally, the respondents indicated that green plants like *Tithonia, Tephrozia, Pytolaca, wondering jew, black jack, Pig weed* and any other plants especially those with nitrogen and poisonous contents are added to the stored human urine in the containers. These plants contain various nutrients as well as chemical contents which are useful to kill the pest which would have attacked the vegetables. They further added that when legume/rotting plants are added into the human urine they rot and add nitrogen and chemical contents into the human urine which are paramount for plant growth and pest control. They acknowledged that the period at which the human urine is stored, and they also stated that human urine was allowed to stay for 2-4 weeks before it is applied to the vegetables. The respondents further asserted that storing human urine for such a time allows it to ferment and reduce its toxicity to plants. This period too, allows the added plants to rot and avail their nutritious contents to plants. The findings concur with Ranasinghe *et al.* (2016) who argue that human urine collected and stored into jerry-cans, legumes/legume plants and any other rotting plants are added into the human urine and left to ferment and as these help to reduce its toxicity to plants.

It was further indicated that when the two or four weeks reach, wood ash is added into the human urine and stirred to have a uniform solution. One of the respondents added that it is very important to add ash as it contains potash and phosphorous which are very useful for vegetable and other plant growth. They further revealed that after adding ash and stirring the human urine, it is diluted with water in the ratio of 1:3. This is in agreement with Pradhan (2010) who stated that a 3:1 mix of water and human urine is an effective dilution for vegetables. However, the dilution may change depending on the crop which it is to be applied. For example, it in the ratio of 1:3, for bananas it is diluted in the ratio of 1:1 while for maize, it is 1:2. These specification imply that bananas require concentrated human urine as compared to vegetables and maize. One of the respondents revealed that she had been applying human urine to mangoes and oranges but she did not dilute it because mangoes and other fruits require concentrated human urine as compared to the other plants. Pradhan (2010) also notes that the correct amount of dilution of the human urine content depends on the soil and the type of vegetables to be well applied to the vegetables.

The final procedure reported for making human urine as a fertilizer was its applicability to the vegetables or other crops. The respondents indicated, that human urine was applied to different crops and using different approaches. They reported that when applying to vegetables, especially those which their top/ upper parts are eaten, human urine was applied at the root base using a ring method. This was supported by Pradhan (2010) who clarifies that human urine is frequently applied to vegetables through a ring method around plants or at the root base. The reasons put forward for applying the human urine at the base was that human urine is not good for the leaves and the fruits which are sometimes consumed as fresh vegetables in form of salads/dissert. One of the respondents reported that people's attitude are easily changed when you talk of human urine being used as a fertilizer implying that when human urine is

applied on leaves, no one can buy or eat the vegetables, thus, farmers incur losses.

4.1. Uses of Human urine as a fertilizer for vegetable growing

To address this objective, the respondents were asked to provide responses on the uses of human urine as a fertilizer in vegetable growing and the responses were; flourishing vegetables, locally available and cheap, lowers costs of production, improves soil fertility, control pests and diseases, repels dangerous insects, reduces product chemical content, increases incomes, increases vegetables yields, reduces food contamination and environmental contamination as indicated in Figure 1 below:

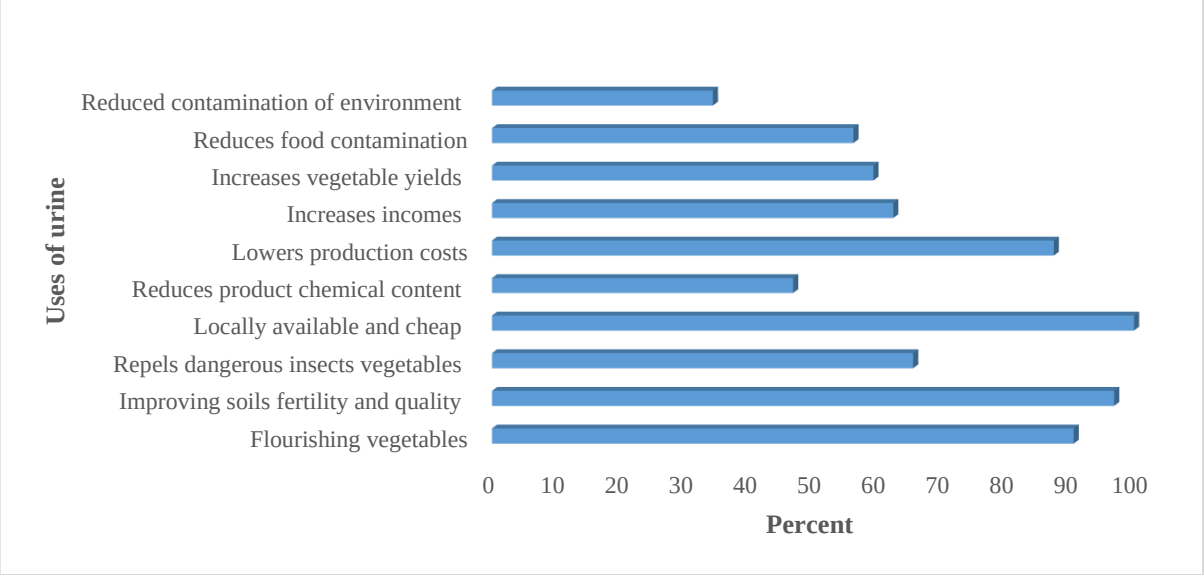

Fig. 1: Uses of Human urine as a fertilizer for vegetable growing

Results in Fig.1 above indicate that majority of the respondents (100%) indicated human urine being locally available and cheap to form the best use to the vegetable farmers in Kitemu zone. This was followed by those who asserted that human urine improves soil fertility and its quality (96.9%), ensures better growth of vegetables (flourishing) (90.6%), and lowers production costs, especially purchasing expensive fertilizers (87.5%). Additionally, 65.6% noted that human urine repels insects in vegetables, 62.5% indicated that human urine increases income of the farmers, vegetable yields (59.4%) while only 56.3% revealed human urine as being useful in reducing food contamination. On the least extend, a few respondents reported human urine to be useful in reducing product chemical content (46.9%) and environment contamination (34.4%).

Results indicated that human urine was being locally available and cheap for use by vegetable growers in Kitemu zone. This meant that human urine was easily produced by family members any time it is required. This assertion is supported by Beaune (2018) who explains that human urine is a locally and constantly available resource and free of charge. Thus, this makes it a highly valuable source of soil nutrient (Ranasinghe *et al.* 2016; Beaune, 2018) content and also human urine is valued at a low-cost practice, which contributes to significant increases in yield and incomes. However, the quantity of human urine required depends on the number of household members. It also depends on the quantity of water taken, type and nature of food eaten. Occasionally, when people drink more water in relation to good weather, the chance for higher quantities of human urine produced is higher as compared to low water intake and harsh weather. Further, a person who eats mattooke or irish potatoes produces much urine as compared to one who eats cassava, millet or posho. This means that to generate much more urine, the household members should eat soft foods and take much water. The results conform to the findings of Pradhan *et al.* (2007) who inform that an individual produces 1–1.5 litters of human urine per day, which depend on the amount of water taken in a day and the nature and type of food eaten. They further assert that the amount of human urine is dependent on his/her feeding habits, the amount of drinking water consumed, physical activities, body size, and environmental factors.

Furthermore, human urine improves soil fertility and its quality since it contains important nutrients like nitrogen, phosphorus and potassium. Pradhan *et al.* (2007) and Eawag, Gensch & Spuhler (2018) support the finding and assert that human urine contains mostly nitrogen (N), phosphorus (P), and potassium (K). They add that human urine has a fertilizer value of N/P/K 18:2:5, and for human urine mixed with flush water, the ratio can be N/P/K/S 15:1:3:1. It was also revealed from the respondents that these elements are from the rotting plants and wood ash added into the human urine. Since human urine is stored for 2-4 weeks, its toxicity is reduced and more nutrients are got, which are key for plant growth. When added to the soil, it ensures the micro bioactivities of the living organisms into the soil for holding the particles together and control erosion.

The living organism are encouraged to decompose the plant material and any other dead matter hence resulting into humus, an organic element for soil fertility. Human urine is beneficial where soils are low in nitrogen (Baanante, 2006) and it has ability to enhance soil fertility, particularly nitrogen, which is a key factor in influencing their acceptability (Snapp *et al.,* 1998).

Likewise, results indicated better growth of vegetables (flourishing) as a results using human urine as a fertilizer by the farmers. It was further revealed that human urine contained important minerals relevant for vegetable growth. It was also observed in the area that those who had grown their cabbage, tomatoes and nakati were growing vigorously dependant on human urine fertilizer. Ranasinghe *et al.* (2016) affirm that human urine is a well-balanced nitrogen rich fertilizer important for plant growth. Beaune (2018) and Upreti (n.d) indicated examples of crops which grew well with human urine including maize, rice, millet, sorghum, wheat, carrots, kale, cabbage, lettuce, bananas, paw-paw, and oranges. This further stipulates that the more is human urine collected, processed and applied to crops, the more the production you expect to get from the garden.

A respondent in Kitemu zone reported that,

> *Human urine is a very good fertilizer which is always available whenever you need to use it for your vegetables. I have been using it now and the crops look really very healthy. It is also cheap because we just get it from the family members. Thus, there is no problem with land better than inorganic fertilizers which are dependent on the food and water taken* (Respondents X, vegetable farmer in Kyambazi).

Moreover, results indicated that human urine as a fertilizer lowers production costs, especially purchasing expensive fertilizers. This implies that even farmers who cannot afford exotic fertilizers will be able to grow their vegetables willingly. Those farmers with infertile soils could use human urine fertilizers to boost their soil fertility and increase their soil productivity. Evidences indicated that farmers did not incur costs for fertilizers, only concentrated on using of human urine and increased their vegetable production. This means that famers were able to collect more proceedings from the sale of vegetables as compared using inorganic fertilizers. Thus, the economic value associated with human urine recycling, through increased incomes from crop sales, was also commonly seen as of great potential (Semalulu *et al.,* 2011). It was also noted that human urine fertilization is valued as a low-cost and low-risk practice contributing to significant yield increases. This suggested important contributions to food security and income, especially for those who have few options in soil nutrient management (Ranasinghe *et al.,* 2016; Beaune, 2018). Results were in relation with Pradhan *et al.,* (as cited in Pradhan, 2010, p.19) who note that human urine is not only an important means to increase the yield, it is also a way to improve the chemical quality of the products.

One of the respondents asserted that,

> *The use of human urine does not involve the continuous or risky investments associated with inorganic fertilizer, since the equipment for collection, storage and application has to be procured only once. Even for farmers who would afford inorganic fertilizer, human urine was used as a strategy to optimize such investment by complementing the input of phosphate and potash fertilizers with nitrogen-rich human urine* (Respondent S, Kitemu zone on 25/3/2019).

Interestingly, human urine as a fertilizer was revealed to reduce food contamination, product chemical content and environmenta contamination. Vegetables and other crops grown using human urine are free from toxicity like lead and other toxins as compared to those grown using inorganic fertilizers and chemicals. The findings concur with (Bhat *et al.,* as cited in Pradhan, 2010, p.17) who justify that the use of human urine as a fertilizer could increase crop yields, reduce the water and food contamination, reduce the amount of fecal contaminated wastewater and decrease the environmental pollution by reducing energy consumption. Further, using human urine is a way that veganic gardeners can cycle back the nutrients from the foods they consume, while also diverting their human urine from the water system where it acts as a pollutant (Veganic Agriculture Network, 2018).

4.2. Limitations to the use of human urine as a fertilizer for vegetable growing

To ascertain the limitations to the use of human urine as a fertilizer in vegetable growing, the respondents were required to reveal limitations to using human urine as a fertilizer and the following were noted; low consumption rate of water and food, cultural beliefs, inadequate knowledge, hygienic conditions, limited space, sickness, suspicion, odour, shame, among other as indicated in Fig. 2 below:

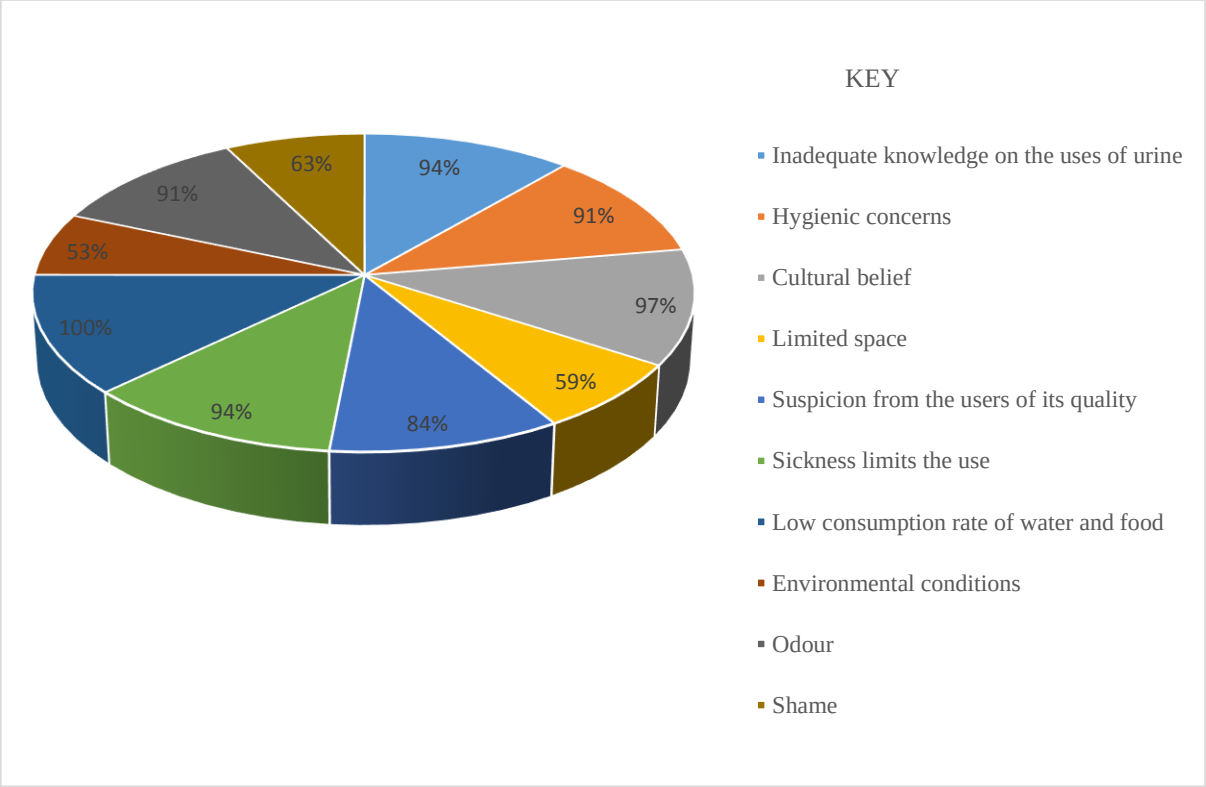

Fig. 2: Limitations to the use of human urine as a fertilizer for vegetable growing

Results in Fig. 2 above, show that 100% of the respondents had low consumption of food and water. This was followed by cultural belief (97%), inadequate knowledge on the use of human urine as a fertilizer and sickness of the people accounting to 94% respectively. On the other hand, 91% of the respondents reported hygienic concerns and odour as limitations respectively. Additionally, suspicion from the users of human urine on its quality (84%), shame (63%), limited space (59%) and environmental conditions (53%) were the limitations to the use of human urine as a fertilizer in vegetable production in Kitemu zone.

Results indicated that low consumption of food and water intake limited the use of human urine as a fertilizer for vegetable growing. This implies that the production of human urine in a human body depends on type and nature of food eaten and as well as the amount of water taken by the person. Respondents revealed that when you eat mattoke you produce more human urine as compared to some who has taken cassava or posho. As it is also evidenced that bananas are made of high percentages of water. Those using it at home as food have much more generated, other factors held constant. Another respondent asserted that when you take much water throughout the day and parts of the evening, you will be able to produce much quantities of human urine in the night. This is also supported by Pradhan *et al.* (2007) who claim that an individual produces 1–1.5 L of human urine per day and this depend on the amount water taken in a day and nature and type of food eaten. It was also revealed that when you drink much beer or alcohol, you produce more human urine. One of the respondents noted that while at the bar he observed those drinking alcohol were frequenting the urinals/toilets for short-calls. However, the challenge is that sometimes when someone is not sober, he/she may fail to manage the human urine which may be generated. Therefore, this means that those families which had no chance to eat soft foods and take much water, had limitations to producing enough human urine which eventually affects its usability as a fertilizer.

In addition, environmental conditions such as high temperatures, windy, rainy among others had an effect on the production and usability of human urine as a fertilizer in vegetable growing. It was revealed that during heavy sunshine or hot-day despite drinking much water and eating soft foods, little human urine is produced. This is because much water is lost from the body through sweat during day and night. On the other hand, the respondents noted that during wet or cold days, the rate of water intake is reduced because the weather is conducive for everyone at home.

They further asserted that,

> *The common thing for us during this time is to take water in the form of tea or chai, but this requires having sugar, which is also expensive and we do not have the money to buy it.*

The respondents also revealed that in the previous day, when someone could not afford sugar, she/he would slice sugarcanes in small pieces, and put into a source-pan and boiled to make tea for the household. However, this is no longer possible because of limited land where

to plant such a number of sugarcanes and it also sounds as a rudimentary practice in the modern era.

Likewise, limited space in Kitemu zone was a hindrance to the use of human urine as a fertilizer in vegetable growing. This was because most of the residents had *bibanja* as their plots. Based on those who participated in the study, majority of them had plots measuring 50x30ft, and a few had plots measuring 50x70ft. This implied that people had small plots which could not provide enough space for collection and storage of human urine for a specified period of time. Evidences show that using human urine as a fertilizer maybe less accepted in urban or peri-urban areas where households' gardens are close to peoples' homes than in rural areas where houses and crop land are kept separate (Eawag *et al.,* 2018). Some respondents revealed that they could manage to collect and store their human urine but their neighbours could always tell them to remove their human urine and pour it away as it was smelling so much for them.

One of the respondents claimed that her human urine was poured by a neighbor after her refusal to remove as per the neighbor's wish. Other indicated that their neighbours could release their domestic animals like goats and chicken to affect/dismantle or pour their stored human urine. When the situation intensified, a case was filed at the police and to the Kyengera town council by those residents who were not storing human urine, and the health officer from the town council stated that you cannot keep such a 'toxic waste' (unhygienic content with odour) in the vicinity of others, this is an abomination to lives of others. However, he did not give guidelines for using human urine as a fertilizer to ensure its usefulness to vegetable growers.

Therefore, unhygienic and odour perceived by the people reduced human urine's usefulness as a fertilizer for vegetable growing. It is noted that if the people have inadequate knowledge on the storage and use of the human urine, they perceive it as unhygienic and ignore its use in vegetable production. Some also have bias in human urine use and this is linked with the beliefs and culture as well as ignorance. Thus, in cases where people demonstrated negative attitude, culture and beliefs, it is hard to reduce possible enteric contamination during human urine collection (Pradhan, 2010). Some of the respondents reported that they could not produce, collect and store human urine because of its smell and flies which result into diseases outbreak. When human urine is kept at home, its odour deters friends/visitors from visiting your home. This is agreed by Sene *et al.* (2013) who assert that stored human urine has a strong smell and some may find it offensive to work with or to have it nearby. One of the respondents testified that for some time she had kept human urine at home, it brought many flies which lead to unfavorable environment conditions.

The results also indicated that those who had negative attitude towards the use of human urine as a fertilizer were ignorant at its management. One of the respondents further asserted that she did not know how the human urine is collected, stored and later used it as a fertilizer vegetable growing. She even asked when human urine had ever been used as a fertilizer for vegetable production? She further insisted that using human urine is against cultural norms and beliefs for their area. This is supported by Sene *et al.* (2013) who assert that social acceptance limits the use of human urine as a fertilizer. Respondents further indicated that the town needs to play a role of community sensitization on the role of human urine as a fertilizer in order for the people to acquire knowledge and skills on collection, storage and use of human urine in vegetable growing.

One of the respondents asserted that,

> *Kale obutamanya kibi nyo, era obwavu butulumira bwerere, lwa butamanya, tulabye nnyo!" This literary meant that ignorance is bad, and we suffer from poverty because of ignorance, it is really bad and we need to blame ourselves not anyone else (Respondent R, Kyambazzi cell, 27/3/2019).*

The respondents further indicated that cultural beliefs should not deny them a right to better nutrition through using human urine as a fertilizer. When cultural and ignorance combine, the community suffers most hence resulting into malnutrition and its effects to children and elderly. Some respondents asserted that it has been our ignorance and culture that have led to us into such a phenomena of poverty when have the gold with us. Results on culture correlate with Kirchmann & Pettersson (1995) who observe that some cultures may opt for use of human urine as a fertilizer, especially for edible fruits and vegetables which might too be introduced to such an innovation in many local communities. Pradhan (2010) also contents that human urine might not easily be accepted as a fertilizer in many societies especially if it is applied on edible plants.

A respondent stated that,

> *From today onwards, I am going to visit those practicing backyard farming and acquire more knowledge in human urine as a fertilizer making and its usability in vegetable growing. This will help me to increase food production at home and fight against malnutrition and disease outbreak in my home (Respondent Z, Kitemu zone, 23/3/2019).*

It was also found out that sickness and suspicion from the users of human urine on its quality as well as shame limited the use of human urine as a fertilizer for vegetable growing. People reported that human urine produced by those with STDs could pose threats to the vegetables and those who eat them. They were suspicious in the way that such human urine could affect the desired quality of the vegetables by the users. Others added that producing, collection and storing human urine was a shame and they feared even to associate with those who collected and stored it for vegetable growth.

On suspicion, Pradhan (2010) reveals that people are suspicious about the quality of the human urine fertilized products.

5. Conclusion and Recommendations

5.1 Conclusion

Based on the field results, majority of respondents had knowledge on the procedures through which human urine turned into a fertilizer for vegetable growing and knew its uses and values to vegetable production. However, those who did not know indicated that resistant to using human urine as a fertilizer was as a result of its odour, culture, low incomes and limited space. The paper, concludes that, if households accept using human urine as a fertilizer, then food production would increase, and improve their well-beings (nutrition and incomes). Human urine fertilizer would increase vegetables' availability, improve dietary status, and reduce non-communicable disease. It is important to note that, even if used only on a small scale, human urine fertilizer increases food security.

5.2 Recommendations

The paper recommends that community sensitization should be undertaken by Kyengera town council to equip all households with knowledge and skills on the use of human urine as a fertilizer, break ignorance, social norms and taboos, KTC should also carry-out capacity building to the identified community members for continuous promotion of values and uses of human urine among the households, establish demonstration gardens in peri-urban areas to offer learning and usability of human urine fertilizer and KTC should ensure gender sensitivity during human urine collection, storage and its application on vegetables.

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