Human Urine: A Viable Source of Organic Fertilizer for Vegetable Production in Nepal- A Reivew

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ABSTRACT

Vegetables are the main source of food and nutrition for the increasing population that should be minimally taken at amount of 75 -125 gram of green leafy vegetables, 85 gram of others vegetables and 85 gram of roots and tubers vegetables every day. The total vegetable production of Nepal is 3301648 metric tons from total cultivated area of 246392 hectares. To fulfill the demand of nation and utilize the export potentiality of seasonal and off season vegetables, there is a need to increase production and productivity. To increase production farmers are utilizing chemical fertilizer, improved technology and hybrid varieties a lot. Excessive and haphazard use of chemical fertilizer brings hazardous effect on health of people, soil, animals and environment we live. The unnoticed human waste urine that causes environmental pollution if unutilized could be used safely by the farmers as the alternative to chemical fertilizer as it is very rich in nutrient content that are essential for plant growth in available form. Human urine is locally available organic fertilizer that could be used as alternative source of chemical fertilizer for the production of vegetables with better product and lessen environmental hazard.

Keywords: Ammonia, human urine, organic fertilizer, urea, vegetable, yield

INTRODUCTION

Nepal is naturally a beautiful country with agriculture as mainstay of economy where 66.7% of people are involved in agriculture which contributes 31% of national gross domestic production (MoAD, 2013). Horticultural sector serves as the main component for commercialization and industrialization of agriculture to raise country economy and contributes 16.75% of Agricultural GDP and vegetable sector alone contributes 9.70% of AGDP (MoAD, 2013). The total vegetable production of Nepal is estimated at 33, 01,648 metric ton from total cultivated area of 246392 hectare (VDD, 2013).

Vegetable production is important to feed the world, to supply essential nutrients for health, to create employment opportunities and to generate income. Demand of vegetable is increasing but the supply is in highly deficit condition. Great variation in physiographic locations and agro climatic conditions of Nepal are boon for growing various vegetables at different seasons of the year (Pandey, 1995). Despite it, Nepal imports various vegetables every year with the expenditure of 2.756 billion Nepalese rupees (MoAC, 2012).

People are attracted towards commercial vegetable farming but they do not have enough organic manure and have to rely on high cost chemical fertilizers which is sourced totally from import. Nepal has been spending billions of rupees every year to import chemical fertilizers (Joshi and Singh, 2004).

Although the rate of application of chemical fertilizer in Nepal is not higher as compared to other countries, but unbalanced and hazardous use is becoming a great threat to the Nepalese

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agriculture. Use of chemical fertilizer deteriorates soil quality, water, plants, human and animal health. The use of chemical fertilizers has now proved to be very hazardous to human health and environment (Shomasundaran *et al.,* 2004). Application of organic fertilizer and manures in the field is the best option to get high quality products and sustainable healthy production from field through eco-friendly way, as organic agriculture have environmental benefits, health benefits and also benefits for maintenance of soil fertility, lower economic burden to the farmers, social cohesion, better taste and long life (Ranabhat, 2008).

There are so many organic alternatives for chemical fertilizers like manures, FYM, compost, human and cattle urines, bone meals, poultry manures, vermin-compost etc., among which human urine is considered the best substitute for inorganic fertilizers. Human urine if discharged haphazardly leads to situations such as surface and ground water pollution, euthrophication, accumulation of salts with harmful impacts on soil health and crop yields, leaving serious impacts on aquatic life due to over loading of organic matter among others (Hussain *et al.,* 2002). Human urine is a natural resource produced by every household which contains mostly nitrogen (N), phosphorus (P), and potassium (K). Urine has a fertilizer value of 18:2:5 NPK (Linden 1997) in easily available form. Nutrient contained in urine are in the ionic form and compares well with that of inorganic fertilizer (Kirchmann and Pettersson, 1995).

According to Vinneras *et al,.* (2006) one adult human excretes 550 kg urine on wet mass (21 kg on dry mass) containing 4000 gm of Nitrogen and 365 gm of Phosphorous in a year. Total population of Nepal in 2011 AD was 26,494,504 with average annual growth rate of 1.4% and 61% of adult. This means if human urine is collected properly only from adult Nepalese it could supply more than 64,646 mt of Nitrogen per year. Highly nutrient richer human urine should be promoted as an alternative to the chemical fertilizer because of it is cheap, locally available and less harm to health and environment than inorganic fertilizers. Therefore, this article presents the review of the research on use of human urine on vegetable production and to extend the findings to the farmers, readers so that the obvious wasted human urine could be utilizes as fertilizer. This paper is to inform about human urine as organic fertilizer, its application method and its effect on production of vegetables.

MATERIALS AND METHODS

Various scientific papers of the related topics are collected from internet, library and scientific publications. Similarly, information was collected from related organizations like Ministry of Agriculture, Department of Agriculture, Vegetable development directorate and others. This is the collective form of the findings.

DISCUSSION

Organic fertilizer, a sustainable alternative to inorganic

In Nepal, use of chemical fertilizer has grown significantly after the deregulation of fertilizer trade in 1997 and the overall use of fertilizer in nutrient terms has increased from 34.7 kg per ha of cropped area in 1997/98 to 57.9 kg ha^{-1} of cropped area in 2000/01, with average annual growth rate of 18.6 % (Khanal and Manandhar, 2005).

Sharma and Agrawal (2004) reported that chemicals enter and get deposited in the fat of our body while eating chemically grown vegetables and drinking polluted water which ultimately causes various dreadful diseases like cancer. The indiscriminate use of chemical fertilizers increases soil acidification, impairs soil physical condition, reduces organic matter content, creates micro nutrient deficiencies, increases susceptibility to pests and diseases, decreases soil lives, increases soil, water and air pollution via agricultural run off and leaching (Joshi and

Singh, 2004). The over-application of chemical fertilizers creates a risk of soil fertility degradation, and causes environmental pollution (Tisdale *et al.*, 1985). The change in the soil pH, soil acidification and lower humic acid contents are some key problems of overuse of synthetic fertilizers. The poor soil respiration rate and complete vanishing of natural decomposer communities from agro ecosystems has questioned the land sustainability and future food security (Suthar, 2008).

Organic fertilizers are animal and plant wastes containing natural forms of plant nutrients which if added to the soil improve its physical condition, replenish its humus content and support soil life. Organic wastes contain varying amounts of water, mineral nutrients and organic matter (Brady and Weil, 2002). There are many types of organic fertilizers among which FYM, animal manures, compost, animal urines, human urines, city waste; poultry manures, bone meal, vermin compost etc are mainly used in farming.

Nutrient content of FYM on average is 1.5% N, 1.0% P_2O_5 and 1.5% K_2O (Tondon, 1995) whereas, nutrient in normally used animal manure ranges from 1.5 to 4 % N, 1 to 1.98 % P and 0.65 to 2.32 % K (Labios and Labious, 1994) . Vermicompost improves the physical and biological condition of soil, improves soil fertility and pulverizes it through their churning and turning action in addition to contributing plant nutrients (0.60-0.66%N, 1.34-1.93% P and 0.40-0.42% K), improves aeration and water holding capacity (Shinde *et al.*, 1992). Average nutrient content of cattle urine collected from gutter of Cattle shed Nepal was 0.49 % total Nitrogen, 3.243µg l-1 total phosphorous, 0.483% total potassium and 7.3pH (Khanal *et al.*, 2011).

Now a day, human urine is increasing its applicability at farmers' level. Human urine is highly rich in plant nutrients on readily available form. Urine used directly or after storage is a high quality, low cost alternative to the application of N-rich mineral fertilizer in plant production. Human urine is a liquid product of the human body that is secreted by the kidneys which contains large amounts of soluble nutrients- macro and micro nutrients (Gensch *et al.*, 2011). Human excretes 0.8-1.5 liters urine per day containing 95 % water, significant quantities of main micronutrient (N 3-7 gram per liter, P and K) and dissolved ions of chloride, sodium, etc required by plants in dissolved forms (Richert *et al.*, 2010).

An adult excretes about 580 kg urine per year with an average of 1.5 liters per day (Morgan, 2003). Urine contents 96.98% water, 0.53% (3.08kg/year) nitrogen mostly urea, 0.04% (0.23kg/year) phosphorous and 0.14% (0.81kg/year) potassium (Gao *et al.*, 2002). They also found that NPK produce from urine (4.12 kg/year) was higher in quantity than faeces (1.63 kg/year). In human urine total nitrogen concentration ranged between (2.66 to 2.68 g/L) with available N form ammonium about 97% of the total N, Total P value ranged between 4.7 to 5 g/l and total K values ranged between 14.7 to 16 g/l (Annan, 2013).

Human urine if not collected Nitrogen in it leached to the ground causing high nitrate in groundwater if consumed causes methemoglobemia (a reduction in blood haemoglobin level) and also stimulates excessive growth of aquatic organism, algal bloom and euthrophication (Silva *et al.*, 2000) so that human urine is best to utilized for crop production. Technical know-how, health effects and socio-cultural perceptions were some of the challenges preventing the full adoption of urine as an alternative for fertilizer use (Cofie *et al.*, 2011) but many researches show that its use is safe.

Collection of human urine

Urine should be collected on close tank to avoid loss of Nitrogen in the form of ammonia. Urine should be collected and stored for 1 to 6 month to reduce the health risk from faecal cross contamination (Richert *et al.*, 2010). Storage of urine at 20^0C for equal or more than 6 month makes urine viruses and protozoa free which could be applied to all crops (WHO, 2006). The pH of urine while excretion is about 6 but at storage degradation of urea to ammonium and carbon dioxide in presence of urease increases it to 9-9.3 (Jonsson et al., 2004)

Application method of human urine

Human urine stored in closed tanks and containers should be spread directly onto the soil to increase nutrient availability, reduce nutrient loss and also to reduce the risk of negative effect of pathogens, heavy metal, pharmaceuticals and hormones present on urine. Richert *et al.* (2010) mentioned that human could fertilize 300-400 m^2 of crop to a level of about 50- 100 kg N/ha from one year's urine collected from oneself.

Urine is better to incorporate into the soil than spraying in air for efficient use of nutrients and reduced loss of N through the gaseous loss of ammonia (Rodhe *et al.,* 2004). To save plant from burning effect on foliage and root apply urine at distance of 10-30 cm apart from planting spot avoiding touch of urine on foliage and roots (Richert *et.al* 2010). Immediate incorporation of urine in topsoil could minimize the ammonia loss to around 5% (Rodhe *et al.,* 2004). Urine should be applied after 2 weeks of planting or emergence of first plant from seedling for vegetables (Richert *et al.,* 2010).

Effect of human urine on vegetable production

Human urine can be used as fertilizer on the vegetable farming to increase yield as replacement to chemical fertilizer. Use of human urine for higher and healthy production of vegetables like spinach, amaranths, cabbage, tomato, sweet peppers etc were done by various scientist in various location.

Increased dry matter yield of cabbage and spinach with the application of human urine upto 200 kg N per hector was mentioned by Mkeni *et al.,* (2006) which was comparable with yield from urea. Morgan (2003) found higher yield of Lettuce, Spinach and tomato on plots fertilized with urine diluted in ratio of water to urine in 3:1 ratio and applied 0.5 liters of dilution 3 times a week than unfertilized plots on Zimbabwe. Lettuce on 30 days yielded 500 gram per plant on urine treated plots as compare to 230 grams per plant of untreated plots. Spinach on 30 days produce 350 gram per plant as compare to plants of unfertilized plots. Tomato on treated plots produces 6084 grams per plants as compare to 1680 grams on plants of unfertilized plots. Richert *et.al.* (2010) from the field trials in Burkina Faso using same rate of Nitrogen nutrient found no statistical difference between yields of egg plant using stored human urine (17.7 ton per hector) and mineral fertilizer (17.8 ton per hector) which are statistically different from yield (2.8 ton per hector) from unfertilized plants. They also found high yield of Tomato by the use of stored human urine (5.2 ton per hector) and mineral fertilizer (5.2 ton per hector) which are statistically different from yield (2.8 ton per hector) from unfertilized plots. Pradhan *et al.,* (2009) urine fertilized tomato plants produced 4.2 times more yield than non-fertilized plants. In addition, urine use is more environmentally friendly and safe even though leaching of excess nutrient is possible if nutrient mismanagement occurs.

Human urine was used in trials carried out in Finland as a fertilizer to supply 180 kg N/ha on cabbage cultivation in comparison with industrial fertilizer and non-fertilizer treatments in which Pradhan *et al.,* (2007) found that growth, biomass, and levels of chloride were slightly higher in urine-fertilized cabbage than with industrial-fertilized cabbage but clearly differed from non-fertilized. They obtain highest average total plant biomass (4.7 kg), commercial biomass (3.5 kg) and head circle (71.4 cm) at urine fertilized plot slightly greater than average total plant biomass (4.3 kg), commercial biomass (3.3 kg) and head circle (68.8 cm) at chemical fertilized plots. Adeoluwa and Cofie (2012) from research on green amaranths (Amaranthus caudatus) concluded that human urine application equivalent to 100 kg N ha^{-1} produces higher total plant yield (58.17 t ha^{-1}) than total plant yield (34.34 t ha^{-1}) in the two plantings. They also found that edible portion of vegetable from plot fertilized with urine did not reveal any significantly different pathological contamination compared to other fertilizer treatments used in this investigation and urine treatment improved soil nutrient exchangeable cat-ions and acidity.

Highest yield (436.03 kg per plant) comparable to inorganically (0.42 mg N/plant) fertilized plant twice a week yield (521.34 kg per plant) was obtain by Anan (2013) from the pepper plant in which human urine (0.45g N/L) was applied once a weak than yield (431.68kg per plant) from urine (0.90g N/L) applied twice a week and yield (416.80 kg per plant) from urine (1.35g N/L) applied thrice a week and also highly greater yield than unfertilized plant yield (138.93 kg per plant). Shrestha *et al.,* (2013) found fruit yield per plant (553.9 g) of sweet pepper (Capsicum annum L.) was obtain from plants fertilized with human urine providing 100 kg N per ha in combination with compost and concluded that human urine performs better when used in combination with compost, and can be used as a promising fertilizer source in sweet pepper production.

Pradhan *et al.* (2010) conducted experimental demonstration in the cultivation of radish, potato, broadleaf mustard, cauliflower and cabbage where urine + ash or manure fertilized plots received 54 kgN/ha for radish, 51 kgN/ha for potato, 81 kgN/ha for broadleaf mustard and 77 kgN/ha for cabbage and cauliflower. They noted significantly higher broadleaf mustard biomass (19.7 ton/ha) from urine + ash fertilizer than biomass from animal manure (9.3 ton/ha) and without fertilization (7.2 ton/ha). The biomass of other vegetables are also better in urine + ash fertilizer than biomass from animal manure i.e. in radish root biomass 46.26 ton/ha compare to 22.5 ton/ha, in potato tuber biomass 1.5 ton/ha compare to 1.4 ton/ha, cauliflowers flower biomass 42.7 ton/ha compare to 24.0 and in cabbage head biomass 30.5 ton/ha compare to 19.3 ton/ha. Their experiment on Ghana on cabbage production shows that dose of 121 kg N/ha from urine produce higher head weight (19.79 ton/ha) than from manure (18.66 ton/ha) only, and also the combination of urine and poultry droplet which supply 121 kg N/ha produce higher head weight (23.40 ton/ha) compare to combination of NPK and poultry droplets (22.58 ton/ha).

Effect of human urine on health and environment

Collection, storage and incorporation of urine on soil minimizes exposure to air that result in less odors due to loss ammonia which protects from air pollution and health hazards. One month withholding period results in substantial risk level reduction and combined with the other barriers in the multiple barrier approach the result will be a risk far below 10-6 DALY for pathogenic bacteria, viruses and parasitic protozoa (WHO, 2006). Urine collected in eco-toilet where human urine and faecal matter collected separately are best way to solve sanitation problem, and this practice also improves the environment and increases the food production (Pradhan *et al.,* 2010).

WHO (2006) put several barrier concept for safe use of urine fertilizer which are 1) source separation to minimize faecal contamination, 2) storage and treatment in order to sanitize urine and reduce microbial health risks, 3) application techniques i.e. reduce direct contact with edible part, 4) crop restriction suggest leafy vegetable are high risky but for stored urine it is not highly reduced 5) withholding period for crop to harvest from last urine application on an average is one month, 6) protective equipment, 7) hand washing, 8) food handling and 9) cooking and health and hygiene promotion.

Very high rate of N application (1600 kg N per hector) supplied from human urine result salt stress to vegetable and lowers yield, increase salinity of soil (Mkeni *et al.,* 2006) so it is less recommended to use high rate of human urine. The few pathogens in urine fertilizer actually applied into the soil are not a high risk for agricultural production, since those pathogens are unable to gain access to the agricultural consumer products (Pradhan *et. al.,* 2007). Urine fertilizer needs to be used with care to reduce any possible risks; it should never be applied directly to any parts of the plants, since, in addition to possible microbial contamination, plain urine can physically damage many plants (Jonsson *et al.*, 2004) Insect damage was lower in urine-fertilized than in industrial-fertilized plots and microbiological quality of urine-fertilized cabbage and sauerkraut made from the cabbage was similar to that in the other fertilized cabbages so that use of urine in cabbage does not pose any significant hygienic threats or leave any distinctive flavor in food products (Pradhan *et al.*, 2007).

Heinonen-Tanski *et al.*, (2007) found higher yield of cucumber yield after urine fertilization which was similar or slightly better than the yield obtained from control rows fertilized with commercial mineral fertilizer and none of the cucumbers contained any enteric microorganisms (coliforms, enterococci, coliphages and clostridia) and concluded that human urine collected in the separated toilet are safe to use in vegetable production.

Urine fertilization has been found to give a temporary set-back to the population of earth worms, but the effect is not permanent and after about 6 months, the population had recovered (Muskolus, 2008). Hormones and pharmaceutical residues are two types of micro-pollutants which occur in urine that could be enter into the human food chain with risk of toxicity but it was safe if urine is applied to the soil instead of spraying (Von Munch and Winker, 2009) The amounts of harmful heavy metals in urine are miniscule and much lower than wastewater sludge or even farmyard manure (WHO, 2006) so it is safe to use human urine on crop production.

CONCLUSION

Vegetables are important for food supply, health and income generation. Chemical fertilizers used in haphazard manner in vegetables cause deleterious effect on human health, animal health, soil health and environment. Human urine which if left unused could cause health hazard of human, soil, animals and environment, but it can be safely used with safe handling including sanitization as the alternative to chemical fertilizers to address the problem of low production, malnutrition and trade imbalance due to import of fertilizers and also the economy of country could be raised through export of organic vegetables. Human urine which contains higher concentration of Organic NPK could be used as organic alternative source to chemical fertilizer for higher and quality production of vegetables.

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