Urine from separating toilets for non-edible plants

Helvi Heinonen-Tanski*, Department of Environmental Science, University of Kuopio, POB 1627, 70211 Kuopio, Finland, email:heinotan@uku.fi, Tel +358-40-3553152

Abstract: Private households or different organisations such as schools, bus terminals, railway stations, municipal offices, market areas etc. might have a separating toilet but they do not have any willingness or possibility to use urine as a fertiliser for edible plants. The same may be also with the public toilets. If the urine can not easily been transported to the close agricultural or horticultural land these urine producers must find some other ways. Anyhow there are several other non-edible plants that can be cultivated in different climates getting joy from ornamentals (as roses) but also for fibre materials, construction materials and timber. In addition some industrial plants might be possible. This paper describes which plants should or could be cultivated if the urine produced as well it deals with some limitations which should be considered.

Keywords: timber, public toilets, urine

Introduction

Sanitation should belong to human rights and be available always as a safe option – also outside of home. Especially women need this service. In areas without sewage nets and waste water treatment plants a separating toilet is a rather good possibility in areas with shortage of water this could be a urine separating dry toilet. Usually human urine is microbiologically pure if it is not contaminated with faeces but there are some pathogens which are emitted to urine, the best known may be schistosomiasis spread via snails living in fresh waters as in dams (Ofoezie, 2002).

If there is fear about the hygiene of urine forming in public separating toilets this urine may best be used for non-edible plants. If the amount of urine is moderate per area and there are no generally known serious phototoxic symptoms. The vegetation area needed for 500 L of urine (theoretically formed in a year by one person) is equal to the land area needed for food production of one person. This area is dependent on climate and it can be 100-500 m^2 in Nordic countries or in tropics under 50 m^2 since many plants grow all the year.

The nutrient content of human urine depends on diet. Thus the human excreta formed by Thai rural people contain approximately half the nitrogen content of excreta from Western countries, since the Thai diet contains less protein than the Western diet (Schouw *et al.,* 2002). People living in tropical climate excrete a relatively higher percentage of nitrogen in sweat and less in urine than people in temperate climate (Huang *et al.,* 1975; Huang *et al.,* 2002). Therefore Western calculations about urine volume and nitrogen content can be assumed to represent overestimations. Furthermore in climates with seasonal heavy rains, soil will regularly be cleaned of water soluble nitrogen and thus the risks of over fertilization with nitrogen are smaller than is the case in Nordic countries. If people eat mainly vegetarian food their excreta contains similar ratios of nitrogen and phosphorus as taken up by plants and this ratio is 10:1 for most plants (Knecht and Göransson, 2004). Thus there are no specific risks for unbalancing plant nutrients if human excreta are used as fertilizers (Pfister and Baccini, 2005). It should be emphasized that the normal urine is a powerful fertilizer but it cannot replace irrigation water.

Tropical vegetation usually has high water requirements. Mean evapotranspirations have been estimated to be some 3-5 mm/day in the tropics (Stöckle *et al.,* 2004); Amin *et al.,* 1997) and thus annually 1400-1500 mm of water can be released by vegetation. Thus a single medium size tree with crown area of 25 m^2 could evaporate daily approximately 100 l.

Material taken from literature to show that improvements to environment are now possible with low costs

The plants selected for this report can be grown in common areas in tropics but many also in other climates. Some of the plant species presented are resistant to permanent water logging and salt stress, which are problems in coastal areas. The plant residual leaves and branches can be used as bedding materials in composts or as fuel, so that women could get more easily firewood which in addition, would mean that more natural forests could be protected. The firewood is economically important for poor people who often must use even half of their income for firewood (Quazi, 2005).

Since the scientific literature released to the fertilization of tropical plants is limited, the fertilizer needs of different plants have been estimated from the knowledge of the energy or protein content in their leaves, fruits or other parts as well as from the growth rate.

As results many plants for many purposes

Plants having potential to destroy host snails or flies spreading schistosomiasis or malaria

Foxtail agave (*Agave attenuate*) originates from Mexico but it is widely cultivated as an ornamental and it can be propagated vegetatively. Its dry leaves contain compounds known to destroy efficiently *Bulinus africanus* (causing schistosomiasis) and *Anopheles arabiensis* (spreading malaria) but less *Daphnia pulex* but it has been in other organisms quite non-toxic (Brackenbury and Appleton, 1997).

Clark and Appleton (1997) found that ***Gardenia thunbergia*** leaf power in water killed *B. africanus* and in addition they recommended that the leaves of ***Apodytes dimidiata*** and possible ***Warburgia saluris*** had so much mollucicidal activity that they could be used against snails. Gardenia is a small South-African ornamental tree with white big flowers. **Apodytes** with its edible red or black fruits can reach 25 m height and grow in dry Sub-Saharan Africa (Lovett *et al.,* 2006).

Fiber plants

Cotton (*Gossypium spp)* is an annual plant and one of the most important plants in tropical and subtropical areas. Cotton seed boll pods can be harvested some six months after seeding and seeding can be done in the tropics at any time. Due to its rapid growth and harvesting of nutrient-rich seed bolls, cotton needs an abundant supply of fertilizers (Sawan *et al.,* 1998, Blaise *et al.,* 2005). The red flowers of cotton are ornamental.

Ramie (*Boehmeria nivea***)**, **jute** (*Corchorus* sp.) and **fiber hemp** (*Cannabis sativa*) are widely cultivated industrial plants. Their fertilizer needs are not well documented, but generally the yield has improved by fertilization (Scheer-Triebel and Leon, 2000; Banik *et al.,* 2003; Patel and Thakur, 2003) and especially by split fertilization (Bhattacharjee *et al.,*

2000). Considering the annual yields and fertilizers used for these plants it seems that too low fertilizer level might often limit the yields. Fiber hemp can be cultivated already in Finland but ramie and jute are tropical.

Textile hemp (*Musa textilis*) grows, as do other bananas, in less than one year and it has smaller size than edible banana. All bananas tend to benefit from good fertilizer status in soil and thus their cultivation could be an interesting possibility, if their leaf stalks can be used making for ropes, nets, hammocks, hats, mats or other purposes (Jensen, 2001).

Kapok, white silk-cotton tree (*Ceiba pentandra*) can reach rapidly up to 30 m in height (Jensen, 2001). It can grow also in poor soils but growth is better if urea and phosphate fertilizations are used (Gupta and Mohan, 1991). Kapok is used as stuffing material in building materials, toys, cloths, textile bags, furniture pillows and other handicrafts. Its seeds are rich in nutrients used as poultry feed (Narahari and Asha Rajini, 2003). As a rapidly growing tree it must benefit from high amounts of nutrients. Partly similar is s**ilk cotton tree, red cotton tree** (*Bombax ceiba* or B. *malabaricum*) is even larger (up to 40 m) than the kapok tree (Jensen, 2001) and its red flowers are decorative. The bark has been used for rope making. In addition, its timber wood is valuable, i. e. this tree is multipurpose.

Mulberry tree (*Morus alba*) leaves are used for silk fiber production by silk worms cultivated also in Central Europe. These trees are usually pruned as small trees or shrubs so they fit to small sites. If the leaves are regularly eaten by silk-worms, which make from leaf protein silk fiber protein, the plant must have a high protein synthesis capacity and a high need of nitrogen. Abbasov and Ataev (1970) have shown that mulberry trees grow better than the non-fertilized controls if 90 or 180 kg/ha/a nitrogen was used. Mulberry tree can't survive if the soil is too alkaline (Gill *et al.,* 1987). Humans could also eat mulberry berries.

Light construction material plants

Rattans (canes) are the names given for many different climbing palms - lianoids (Jensen, 2001). These plants usually need a trunk on which they can climb. Rattans grow rapidly and thus they would benefit from urine fertilization. Rattan products are popular for making light furniture, baskets, toys or sport items (Chan, 2000) sold also in Western countries.

Bamboos (*Bambusa vulgaris* and many more species from different genera) are rapidly growing grasses (Chan, 2000) and some of them can grow to over 30 m (Jensen, 2001). Different bamboos are used for the construction of houses, fences, supporting poles for climbing plants, furniture, baskets, musical instruments, and sport goods. They can even be used for plywood or paper making. The very rapid growth of bamboos means a high nutrient need. Private farmers have cultivated bamboo using human excreta and earned well money from this production (Quasi, 2005). Some bamboos are cultivated also in Finnish climate.

Oil palm (*Elaeis guineensis*) is a common 20-30 m tall tropical tree. It is an important industrial plant since its seed oil is used for food processing and making soap (Jensen, 2001). In addition it is cultivated in big farms to make biofuel for car gasoline. Palm leaves are very often used for roofing, walls or fences. The young leaves and press cake fiber can be given to animals and on the other hand urine and feces from grazing cows and goats has found to be a good fertilizer for oil palm and these excreta improved soil structure (Devendra, 2004).

Real timber trees are beneficial but the restrictions by CITES-lists must be respected

Timber tree seedlings are produced in nurseries and there nurseries could use urine. Several timber trees and their leaves can be used as firewood or fodder, and the bark can be used as medicines or for tanning. In some cases there are also fruits or seeds, which are utilized by people or animals. Trees give shadow and act as windbreaks. They are important in creating an attractive landscape. The cultivation of tall trees can also protect the natural coastal mangrove forests, which are extremely important for controlling against major storms and flooding as well as reducing the effect of high waves or tsunamis as occurred 26 December, 2004 and reported by FAO (2005).

The trees are useful for improving the soil properties. The root activity and the falling leaves increase soil organic matter content as has been reported by Osman *et al.* (2001) and roots bind soil and make it less erosion-sensitive. Thus trees can control water erosion.

Before cultivating tropical trees, it is essential to consider the **CITES-list** (Convention on International Trade in Endangered Species of Wild Fauna and Flora) supervised by the United Nations Environmental Programme. This agreement is aimed at preserving the environment so that rare and vulnerable animals or plants are protected. Many valuable tropical timber tree species have been placed on this list in order to save the natural forest from illegal felling. Often industrial countries demand a certificate to show that a plant on the CITES-list has been cultivated in a way which is ecologically and environmentally acceptable. Therefore, if a tree species is placed on the CITES-list, it requires a certificate of the governmental authorities. The CITES-lists are different in different areas and can be found from the web site http://www.cites.org/index.html . Some very vulnerable plant species are placed on the red list (see www.wcmc.org.uk/species/plants/red_list.html). One certification system is supervised by FSC (Forest Stewardship Council) and this certification system is accepted by European furniture makers.

Roseapple (*Syzygium jambos*) is an ornamental fruit tree but its fruits are not considered to be tasty and they are used as raw material for rosewater and leaf oils can serve perfume industry. This tree is some 10 m high so that it can be cultivated in small yards. The heartwood serves as good timber (Jensen, 2001). This tree thrives in wet conditions and it tolerates also waterlogged areas.

Indian jujube (*Ziziphus mauritiana)* is a small tree (15 m high) growing even in soils which are occasionally waterlogged or arid. The reddish timber is used for turnery products. This tree can be cultivated to feed lac insects (*Coccus lacca*) producing shellac (Jensen, 2001).

Cempedak *(Artocarpus integer*) is a fruit tree (typically less than 20 m high), but its wood is valuable and durable as timber and its latex can also be used. Thus it is similar to its botanical relative jackfruit tree *(Artocarpus heterophyllus*), which is well-known as a medium sized (20-30 m high) fruit tree. In addition, cempedak leaves can serve as animal feed and its bark as tannin for leather. The timber is known to be termite resistant and a medium hardwood. Both *Artocarpus* species are used in making furniture, boats and for house construction.

Neem tree (*Azadirachta indica* or *Melia indica*) grows in many places including wastelands and even highly alkaline soils fertilized with urea (Gill *et al.,* 1987). The tree is usually less than 20 m high but the trunk can be as wide as 1 m in diameter (Jensen, 2001) and since the

wood is said to be insect repellent it is very valuable for construction. Furthermore, its seeds and leaves can be used as an insecticide (Rao *et al.,* 1992) and the leaves are used as animal fodder. The plant has also medical and cosmetic value. A high lime content of the soil can cause chlorosis in the neem tree (van den Burg and Kopinga, 1983). Neem trees are growing well utilizing urinal wastewaters in a Bangladesh girl school (Heinonen-Tanski, 2006).

Indian almond (*Terminalia catappa*) is often cultivated along streets as an ornamental tree in the subtropics and tropics (Mattila and Virolainen, 1995). It is native to the East Indies (Jensen, 2001) and popular also in the Caribbean, where it has been described to be fast-growing and tolerant to marine wind or salt spray and to be a good provider to shade (Morton, 1985). It grows to approximately 25 m in height. The timber is multipurpose for building or firewood. The leaves can be given to cattle or silkworms. It is a pioneer species growing on disturbed soils and in beach forests. Its kernels are rich in fat (>50%) and protein (>25%). The kernel oil can be used for medicines, soap, animal fodder or human food.

Teak *(Tectona theka or T. grandis)* is very well-known timber wood having high market value cultivated in many countries. The trunk grows straight up to 25-30 m high and 1-2.5 m with diameter. This tree with its big leaves is often cultivated along streets and yards. The wood is used for furniture, house frames, boats, bridges, rails and floodgates. Jensen (2001) recommends that this tree should be cultivated together with Borneo teak or bamboos. It grows well and rapidly with sufficient fertilization (Bhumibhamon *et al.,* 1981). Shortages of nutrients reduce the growth rate and this is reflected in chlorosis and other symptoms (Zech *et al.,* 1991). This tree is on the CITES list. In some countries it is forbidden to export raw teak, since wood-processing provides work and income for local people.

Yemane *(Gmelina arborea)* prefers a fertile soil. The trunk can be wide and the height can be up to 40 m (Jensen, 2001). The wood can be used for many purposes but also as fuel wood. Its flowers are beautiful. The leaves can be used as fodder for ruminants and the tree has also medicinal value. Improving growth was reported in a fertilization test (Otsamo *et al.,* 1995), even though it can also grow in poor natural soils (Zech *et al.,* 1991). This species is on the CITES list in some countries.

Borneo teak or **Malaccan ironwood** (*Intsia bijuga*) is a large tree (up to 45 m) with the diameter of up 2 m. It requires a good water supply so it grows often on river banks, seashores and swamps. This wood is viewed as a "premium" tree for flooring, stairs, windows or door frames etc. (Jensen, 2001). Furniture made from this tree is sold under the name merbau. This plant belongs to *Leguminosae* so it lives in symbiosis with rhizobia bacteria, which have an ability to fix nitrogen. This species is on the CITES list.

Big-leafing mahogany (Honduras mahogany or true mahogany) *(Swietenia macrophylla)* is a source of extremely valuable timber used in the fine furniture and musical instruments, boats etc. The bark tannin is used for leather tanning. The tree can grow up to 40-60 m high with a branchless trunk to 18-25 m and 2 m diameter with buttresses to 5 m (Jensen, 2001), and thus it needs plenty of space. This tree originated from Central America and the wild tree has been set on the CITES-list to protect it from illegal felling. There is a special mahogany program in the CITES programme, i. e. in this case a certificate is mandatory. The cultivation of mahogany seedlings has been shown to succeed better if they receive at least some nitrogen (Yao, 1981), potassium, water and light (Dünisch *et al.,* 2002) but its growth is not rapid (Otsamo *et al.,* 1995). It can suffer heavily from nutrient deficiency in calcareous soils (Zech *et al.,* 1991) and too low levels of nitrogen, phosphorus and magnesium could

disturb its growth. Wood ash tends to contain too large amount of calcium, and therefore ash must be avoided. There are also other mahogony like slowly growing trees in Africa.

Small-leafing mahogany (*Swietenia mahagoni*) is clearly smaller than the big-leafing mahogany (only 30 m high) but it is as valuable as big-leafing mahogany and in practice the timbers from these tree species are not always separated from each other. Since it has more branches the timber of small-leafing mahogany is more interesting than that of big-leafing mahogany but also more difficult to work with. Also this tree can be cultivated legally but there has to be a CITES-certificate if it is to be sold on the Western market. Due to its smaller size, this tree could possibly be cultivated in a smaller space.

Discussion

As presented there are many different plants which could grow with urine. Thus one can do a question: which plant should be chosen? The selection can be done first by considering if the main reason is to get a new, economic resource from fertilizers for poor areas or if the main reason is to reduce contamination of waters considering eutrophication, enteric diseases, schistosomiasis and malaria. Fiber plants and light construction plants may be a good selection giving yield soon and giving handicraft work for women with low capital. Big trees can be a better selection if the protection of groundwater is seen as the major reason. Big trees needing a long growing period may also fit for public places where they need plenty of place but where they are important for landscape.

The selection of a suitable plant could be based secondly on the size of available site. If there is a sunny open space in the vicinity of roads, ponds or rivers, even the very large trees may be suitable bearing in mind that the cutting of a large tree needs more space and its growth time can take decades. The large trees can of course be cut before they have reached the full size; should the space be needed for some other purposes. It is also possible to prune only one or a few branches to get some money.

It is also important to consider whether there will be water-saturated conditions or if there will be dry seasons, which the plant must tolerate. The possible salt tolerance should also be estimated.

In many cases it would be useful to cultivate many different plant species as some herbs and some trees possibly at different growth phases so that harvesting could be done at different times. Small herbal species can often be harvested already after a few months, providing work also for women. On the other hand, the circulation times of many timber species can be 10-20 years, and in extreme cases, even 60 – 150 years.

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