Impact of Human Urine Contamination on Soil Biota

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Abstract

The role of human urine as an organic pollutant to soil biota was examined in this study. Using standard methods, the impact of human urine on the physicochemical parameters, fauna and microbial load in the soil microcosm was considered. Ten replicates of Urine contaminated soil (UrCS) and Uncontaminated Agricultural soil (UnCS) samples respectively were collected from points pedestrian urine deposition within Olabisi Onabanjo University, Ago-Iwoye and University of Agriculture, Alabata both in Ogun State. pH was determined using the pH meter. Moisture content (MC) was determined by drying and difference in weight method. Organic Carbon (OC) was determined using the Walkey-Black method and Organic Matter (OM) was estimated by the formula %OC = %OC x 1.729. Phosphate and nitrate concentrations were determined by spectrophotometric method while sulphate concentration was determined by the turbidimetry method. Ammonium concentration was determined by distillation method using 40% boric acid with methyl red indicator. The fauna record was conducted by heat extraction into alcohol or normal saline while microbial load was estimated by the pour plate and serial dilution techniques. UrCS recorded a significantly higher MC, OC, OM, phosphate, nitrate, sulphate, ammonium concentrations and lower pH ($p<0.05$) than UnCS. A complete absence of microfauna (protozoa), mesofauna (mites, lion ants, insects, insect eggs) and macrofauna (beetle, beetle caterpillars, millipedes, pill millipedes, earthworms, earthworm castings) was recorded in UrCS while UnCS samples recorded their presence. UrCS recorded a significantly lower ($p<0.05$) microbial loads than UnCS. The most adverse impact of human urine on soil biota is the lowered pH and increased acidity which unleash a vicious cycle on soil biota persisting as long as urine deposition continues unhindered on the same spot.

Keywords: human urine, soil fauna, microbial load, impact, vicious cycle

Introduction

Despite soil being the habitat for the majority of earth's terrestrial species, far less attention has been paid to understanding maintenance of soil biodiversity until recently as pointed out by Wardle (2002). Now, there is a growing interest in the belowground biodiversity, largely as a result of advances in techniques that enable more ready characterization of these belowground

diversity (Blaxter and Floyd, 2003; Young and Crawford, 2004) and also because of the increasing recognition among ecophysiologists that soil biota play key roles in ecosystem functioning, especially organic matter turnover, nutrient mineralization (Hooper *et al*., 2000; Wardle, 2002; Heimsbergen *et al.,* 2004; Wardle *et al.,* 2004; Bardgette *et al.*, 2005) and material flow through the ecosystem (Bardgette *et al.,*2005).
Healthy soil played a major role as habitat for various forms of living things ranging from microflora, microfauna, mesofauna, macrofauna to megafauna. And these group in turn by their activity help to maintain a healthy, fertile and productive soil by breaking down organic wastes into bioavailable nutrients which aid plant germination and growth.

Soil fauna activity are essential for the functioning of all terrestrial ecosystem, they are important in the physical and chemical transformation of litter, maintenance of soil fertility and sustained productivity. Hagiar (1994) and VanStraalen (1998) had earlier pointed out that soil fauna respond to different environmental stress through changes in species or community structure hence can be used as an important indicator of contaminated, polluted or healthy soil.

The use of by-products of vegetable, animal and human origins to restore or to increase soil fertility has been well known for over 2000 years and as pointed out by Clapp *et al*. (2005) there has been an exponential increase in deposition of organic materials from municipal solid wastes, sewage sludge and agro-industrial wastes. Millions of tonnes of organic matter are land-filled or incinerated and transformed into methane, carbon dioxide, nitrogen oxides and sulphur oxides.

Though much study on organic pollutions and their resultant effect on the soil environment have been conducted, not much information are available on the impact of urine on soil environment especially of human origin. Human urine in itself is not toxic except when mixed with faeces in septic tanks (Ecosan Publication, 2008) and have been used as fertilizer for over 6,000 years (Halbach, 2008). Kaiser stated that a lot of nitrogen in manure come from urea which is contained in urine as such human urine is a rich source of organic fertilizer.

Urine is a filtered product of kidney which contains only low molecular weight substances and at excretion the pH is normally around 6 but can vary between 4.5 and 8.2 (Lentner *et al.,* 1981). It was further shown by Lentner *et al.* (1981) that of the Nitrogen constituent of urine 75-90% is excreted as Urea and the remainder as ammonium and creatinine. In the presence of urease, urea is quickly degraded to ammonium and carbon dioxide and the hydroxide ions produced will invariably increase soil pH to 9 – 9.3 and this usually occurs within hours of deposition (Vanneras *et al.,* 1999 and Jonssen *et al.,* 2000). But the continual deposition of urine at a spot lead to net acidification of the soil because the conversion of ammonium (NH_4) to nitrate (NO_3) involves release of protons, thereby promoting acidity.
Whitehead and Bristow (1994) reported that the presence of urine of cattle origin in soil inhibited pasture response and there is a marked decline in soil pH in the urine patch following nitrification. This had earlier been demonstrated by Ball *et al.* (1979) that application to pasture of urine from beef cattle resulted in soil acidification.

In Nigeria, urine deposition in public places go on unchecked and has become a menace, a close examination of such soil macrocosm reveals patchiness of soil, obvious discolouration, pungent ammoniacal smell (pers comm.). There is therefore the need to establish the impact of human urine deposition on soil biota. The aim of this study is to determine the impact of human urine on soil microenvironment viz impact on soil fauna, physicochemical parameters and soil microflora.

Materials and Methods

Study Location

The study was first conducted in April – May, 2008 at Olabisi Onabanjo University Campus, Ago-Iwoye, latitude $7^0$30'N and longitude $4^0$32'E, altitude of 76m above sea level with a mean annual rainfall of 1779mm and temperature of 27 ^{0}C. The same study was repeated May – June, 2011 at University of Agriculture, Abeokuta located between latitude $7^0$12'N - $7^0$20'N and longitude $3^0$12'E - $3^0$28'E, altitude of 76 m above sea level with a mean annual rainfall of 1,037mm and 34.7 ^{0}C.

Sample Collection

Ten replicates of soil samples were collected from ten points of pedestrian urine deposition within the Olabisi Onabanjo mini campus and University of Agriculture (hereby called Urine Contaminated Soil, UrCS) and 10 samples from Uncontaminated agricultural soil (hereby called Uncontaminated Soil, UnCS). The soil samples were air dried for two days, sealed in separate polythene sachet and transferred to the soil laboratory.

Physicochemical Analysis of Soil

At the laboratory, 2mm and 0.5mm mesh-size sieves were used to sieve the soil samples. The sieved soil samples were analysed for pH, Moisture content (MC), organic carbon (OC), organic matter (OM), phosphate, ammonium, nitrate, sulphate. pH was determined using the pH meter. MC was determined by drying and difference in weight method. OC was determined using the Walkey-Black method and % OM was estimated by the formula %OC = %OC x 1.729. Phosphate and nitrate were determined by spectrophotometric method while sulphate was determined by the turbidimetry method. Ammonium is determined by distillation method using 40% boric acid with methyl red indicator.

Fauna Records and Microbial Loads

Soil fauna such as insects, worms and arthropods generally were analysed using heat extraction into alcohol while nematodes, cysts and other protozoan were extracted using normal saline. The extracts were then viewed under the microscope to determine their presence or absence. The bacterial load was determined using the pour plate technique and serial dilution using nutrient agar while potato dextrose agar was used for the fungal count.

Statistical Analysis

Using the statistical package SPSS version 17.0, the means and standard deviations were calculated for all results obtained. The means were compared using t-test and significance was established at a probability level of $p < 0.05$.

Results

The Organic matter (OM), organic carbon (OC), Moisture Content (MC), PO_4, NH_4, NO_3 and SO_4 were significantly higher ($p<0.05$) in urine contaminated soil (UrCS) than uncontaminated soil (UnCS) samples while pH was significantly lower ($p<0.05$) (Table 1).

There was complete absence of microfauna (protozoa), mesofauna (mites, lion ants, insects, insect eggs) and macrofauna (beetle, beetle caterpillars, millipedes, pill millipedes, earthworms, earthworm castings) in urine contaminated soil (UrCS) while uncontaminated soil (UnCS) samples recorded their presence (Table 2).

The microbial load viz total viable count, total coliform count, total fungi count and total yeast count recorded from urine contaminated soil (UrCS) were significantly lower ($p<0.05$) than that recorded from uncontaminated soil (UnCS) samples (Tables 3).

Table1: Descriptive Statistics and Independent t-test of Physicochemical parameters between Urine Contaminated and Uncontaminated Soil Samples

Physicochemical Parameters	UrCS Mean±SD (N=10)	UnCS Mean±SD (N=10)	t-statistics	Sig.
Organic Carbon (OC)	0.995±0.059	0.569±0.059	16.16	<0.05
Organic Matter (OM)	1.706±0.103	0.979±0.102	11.24	<0.05
Moisture Content (MC)	14.90±1.79	7.86±0.84	15.826	<0.05
PO4	0.045±0.005	0.022±0.006	9.22	<0.05
NH3	0.017±0.001	0.010±0.001	12.36	<0.05
NO3	0.009±0.004	0.004±0.001	25.15	<0.05
SO4	0.005±0.002	0.002±0.001	50.13	<0.05
pH	5.00±0.20	7.86±0.84	-15.52	<0.05

Key: UrCS: Urine Contaminated Soil; UnCS: Uncontaminated Soil

Table 2: Faunistic Record of Urine contaminated and Uncontaminated Agricultural soil

Fauna	UrCS	UnCS
Microfauna		
i. Protozoa	Absent	Present
Mesofauna		
i. Mites	Absent	Present
ii. Lion ant	Absent	Present
iii. Insects	Absent	Present
iv. Insect eggs	Absent	Present
Macrofauna		
i. Beetle	Absent	Present
ii. Beetle larvae	Absent	Present
iii. Millipede	Absent	Present
iv. Pill millipede	Absent	Present
v. Earthworm	Absent	Present
vi. Earthworm Casts	Absent	Present

Key: UrCS: Urine Contaminated Soil; UnCS: Uncontaminated Soil

Table 3: Descriptive Statistics and Independent t-test of Microbial Load in Urine Contaminated and Uncontaminated Soil

Microbial Load	UrCS Mean±SD (N=10)	UnCS Mean±SD (N=10)	t-statistics	Sig.
Total Viable Count ($x10^4$)	28.50±15.78	153.00±54.27	-6.966	<0.05
Total Coliform Count ($x10^4$)	3.71±1.25	61.50±51.51	-3.546	<0.05
Total Fungi Count ($x10^4$)	3.60±1.89	11.40±1.84	-9.338	<0.05
Total Yeast Count ($x10^4$)	3.00±0.89	15.60±5.66	-5.897	<0.05

Key: UrCS: Urine Contaminated Soil; UnCS: Uncontaminated Soil

Discussion

Generally, the result of the study revealed that human urine has great impact on soil microcosm. Physical examination of the soil showed that the colour of urine contaminated soil is much darker than the uncontaminated soil and this may be an indication of the high level of organic carbon and organic matter contained in the urine contaminated soil.Further physical examination of the urine contaminated soil revealed patchiness of such soil and no plant growth was observed despite the significantly higher levels of nutrients in urine contaminated soil. The significantly higher moisture content of urine contaminated soil is as a result of low volatility & high viscosity of urine and also because the high organic carbon and matter contained therein tend to have high affinity for water.

Urine Contamination, Increased Soil Acidity and Impact on soil fauna and Microorganisms

The major physical impact of urine deposition on soil is the significantly lower pH, indicating high soil acidity. This is as the result of microbial oxidative process of urea which takes place in urine contaminated soil.

$CO(NH_3)_2 + 2H_2O \rightarrow (NH_4)2CO_3$
$(NH_4)2CO_3 + 8O \rightarrow 2HNO_3 + H_2CO_3 + 2H_2O$

The high acidity will greatly interfere with nutrient cycling between soil, air and water to the extent that higher deposition and dissolution of nutrients will occur in urine contaminated soil, hence the significantly higher content of PO4, NO3 and SO4 recorded from urine contaminated soil. It was earlier revealed that when soils become acidic their capacity to adsorb cations is reduced, hence the loss of such cations from the soils by leaching while N, P and S remain immobilised for longer in the soil organic matter. Furthermore, the form of nitrogen taken up by plant roots may be NH_4^+ instead of NO_3^- because nitrification is inhibited. All these and the increased deposition of cations such as Al and Mn results in the creation of adverse growth environment for both flora (micro) and fauna (micro, meso and macro) in urine contaminated soils therefore, leading to their death and possibly migration.
The above assertions probably resulted in the observed patchiness of soil with the absence of plant growth or death of germinating or growing plants. Not only this, the microbial load viz total viable count, total coliform count, total fungi count and total yeast count were significantly lower ($p<0.05$) in urine contaminated soil. In addition, the absence of microfauna (protozoa), mesofauna (mites, lion ants, insect eggs) and macrofauna (beetle, beetle larvae, millipedes, earthworms, earthworm castings) was also an indication of the adverse effect of the soil acidity which impinge negatively on the physiology of these soil dwelling fauna leading to their death or dispersal from such soils.

The Vicious Cycle

As long as urine deposition continues unabated into our soil microcosm, a vicious cycle is set in motion whereby the increased urine deposition leads to increased soil acidity which in turn leads to the impairment of the living environment of soil organisms and in turn leads to drastic reduction in the population of soil organisms. The reduction in soil microbial load and complete absence of fauna leads to the drastic increase in soil organic carbon, organic matter, phosphate, nitrate, sulphate and ammonium to levels far exceeding the threshold thereby leading to the interference with the biogeochemical cycles of these nutrients. This means there is more nutrient loads in the soil than needed making them to become toxic to the living organism and this eventually culminate in the total impairment of the soil health (Fig 1).

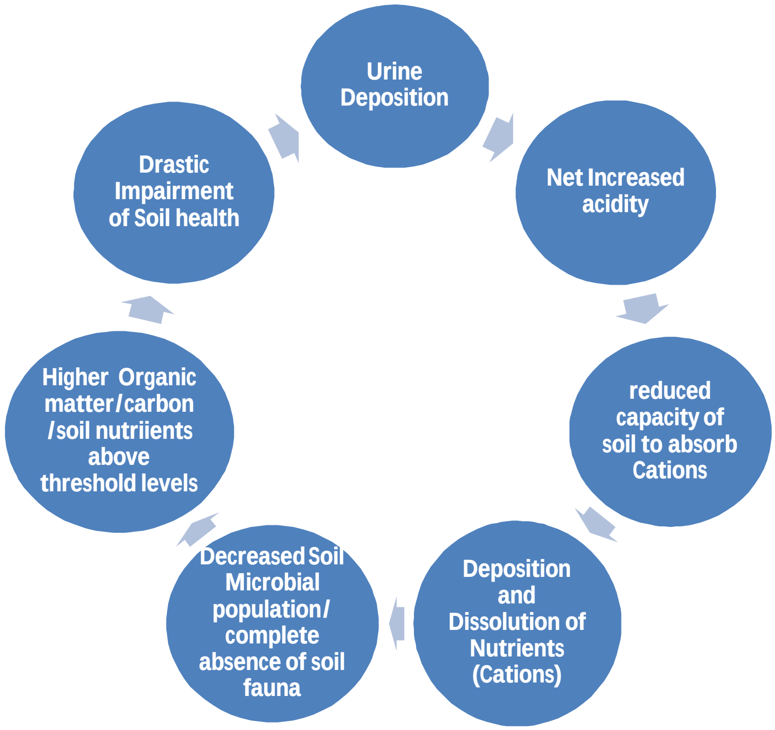

Fig 1: The Vicious Cycle of continuous Urine deposition on soil microcosm

In conclusion, it is evident that continuous deposition of human urine at a spot in the environment has negative value on the health of soil biota and is aesthetically unsightly. It is therefore necessary to prevent the indiscriminate deposition of human urine on soil biota and at public places by providing functional urinary at different points of easy accessibility for pedestrians. Furthermore, soils from such public urinary could be collected periodically, sun dried and used as organic fertilizer, since this study has revealed that such soils are rich in organic nutrients. Further study should be conducted on this beneficial aspect of human urine deposition on the soil.

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