An assessment of the health and ecological risk profiles of Sanjeevak and its fertilizing effect on cucumber biomass production

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Abstract
Permanent cultivation of the land is resulting in soil fertility decline in most agricultural systems in sub-Saharan Africa because most small-scale farmers cannot afford chemical fertilizers. The search for viable and cost-effective alternatives to improve soil fertility for sustainable crop production has resulted in renewed interests in the recycling of organic waste materials. However, concerns about health and environmental risks linked with their application to cropland may have restricted their use. The aim of this study was to assess the fertilizer value of Sanjeevak, its health and ecological risks and its effects on cucumber biomass production under greenhouse conditions. The results showed that the assessment of Sanjeevak revealed that none of the heavy metal and feacal coliform levels measured exceeded permissible limits for application to cropland. Equally, the study revealed that if applied at the proper agronomic rates; Sanjeevak can potentially be as effective as commercial fertilizer for crop production.

Key Works
Health and ecological risk profiles, cucumber, biomass production

Introduction
The search for viable and cost-effective alternatives for soil fertility improvement for sustainable crop production has resulted in the recycling of waste materials; including human and animal excreta. The fertilizing values of organic wastes such as animal manure and humanure are being used to varying extents for crop fertilization in many countries such as Zimbabwe, and South Africa. Hence, animal wastes combination such as Sanjeevak are being utilized for agricultural production. Sanjeevak is a fermented product made up of cattle faeces and urine; it has shown significant promises in field studies in India to improve seedlings development and the yield of various crops (Kate and Khadse 2002).

Objectives
The aim of this study was to evaluate the characteristics of Sanjeevak in terms of its heavy metal contents, total coliform concentrations; in comparison to the requirements for the agricultural use of wastewater sludge provided in the South African legislation. Also, the study reported herein was carried out to assess its fertilizing effects on growth parameters and biomass production of cucumber.

Materials and Methods
Sanjeevak preparation
Fresh dairy cattle droppings and urine were collected at the University of Stellenbosch experimental Farm. Cattle excreta and urine were mixed with water in the following proportions (1:1:18) and then fermented with molasses. The fermentation of Sanjeevak took place under aerobic conditions and kept at room temperature for a period of ± 45 days and replicated four times.

Analytical methods
Fifty-two days after sowing, all plant materials from each treatment (Control/Sanjeevak/Inorganic fertilizer) were harvested for plant height, shoot and root fresh and dry weight measurements. Total N, P and K concentrations were determined using atomic absorption spectrophotometer. Analysis was performed according to South African National Standard for the detection and enumeration and feacal coliform bacteria in wastewater (SANS 9308-3:2004).

Pot experiment
The treatments were 0.11% N, 0.007% P and 0.063% K; which translated to 1.1g N, 0.07g P and 0.63g K per 1000 ml of Sanjeevak. Mineral fertilizer of the same NPK concentrations as that of Sanjeevak was formulated as a source of inorganic fertilizer and translated into 3.14g NH_4NO_3, 0.3g KH_2PO_4, and 1.14g

KCl per pot experiment. The experiment had a total of three treatments for test crop, which were arranged in a randomized complete block design (RCB) and replicated ten times.

Results

The levels of heavy metals are generally very low in excreta, depending on the amounts present in consumed products. Equally, heavy metal contents in urine tend to be low depending on consumed food, probably because they are filtered by the kidneys when they enter the human body. This may explain the level of heavy metals recorded in Sanjeevak. Our results showed that the levels of feacal coliform (Table 2) found in Sanjeevak and heavy metal (Table 1) did not pose any potential health and environmental risks when used for cropland amendment (Table 3) (Snyman and Herselman 2006).

Table 1. Total concentrations (mg kg^{-1} dry weight) of heavy metals in dried Sanjeevak, compared to different classes of the pollutant in wastewater sludges (Snyman and Herselman 2006).

	Pollutant Class			
(mg/kg)	a	b	c	Sanjeevak
Arsenic (As)	< 40	40 - 75	> 75	n.d
Cadmium (Cd)	< 40	40 - 85	> 85	n.d
Chromium (Cr)	< 1200	1 200 - 3 000	> 3000	0.03 ± 0.01
Copper (Cu)	< 1500	1 500 - 4 300	> 4300	0.86 ± 0.18
Lead (Pb)	< 300	300 - 840	> 840	0.03 ± 0.01
Mercury (Hg)	< 15	15 - 55	> 55	1.76 ± 0.09
Nickel (Ni)	< 420	420	> 420	0.14 ± 005
Zinc (Zn)	< 2800	2 800 - 7 500	> 7 500	4.74 ± 0.92

Table 2. Total feacal coliform counts in dried Sanjeevak (cfu/g weight dry matter), compared to microbiological classes in wastewater sludges (Snyman and Herselman 2006).

	Microbiological class			
	A	B	C	Sanjeevak
Feacal coliform (CFU/g dry)	1000 - 10 000	1×10^6 - 1×10^7	$>1\times10^7$	1.2×10^2 - 2×10^4
Helminth ova (Viable ova/g dry)	0.25 - 1	1 - 4	> 4	N/A

N/A: Not Applicable

Table 3. Summary: Permissible utilization of sludge in agricultural applications (Taken from Snyman and Herselman 2006).

South African Sludge Classification		Is agricultural use an option?	Any additional restrictions and requirements	Notes
Microbiological class	A	Yes (i)	No	Could potentially be used as sealable product.
	B	Qualified yes (ii)	Yes	General restrictions/requirements apply.
	C	Maybe (iii)	Yes	General restrictions/requirements apply.
Pollutant class	a	Yes (i)	No	Could potentially be used as sealable product.
	b	Qualified yes (ii)	Yes	if the soil analysis is favourable.
	c	No (v)	Not applicable	May not be used in agricultural practices.

The effects of Sanjeevak application on cucumber growth and biomass production

Application of similar concentrations of Total NPK for both Sanjeevak and chemical fertilizer treatments, resulted in cucumber total biomass production increased relative to the control. Cucumber total biomass obtained 7 weeks after planting (WAP) was generally higher for both sources; with consistently greater yields from Sanjeevak. Equally, the heights of cucumber plants grown in Sanjeevak were greater and significantly different ($P<0.05$) from those of plants grown in inorganic fertilizer and the control (Figure 1). Cucumber root and shoot weights were greatest in Sanjeevak treatment. Taking the control as the baseline, cucumber biomass (Table 4) increases of about 3.5 and 2.2 times were obtained under Sanjeevak and inorganic fertilizer treatments respectively.

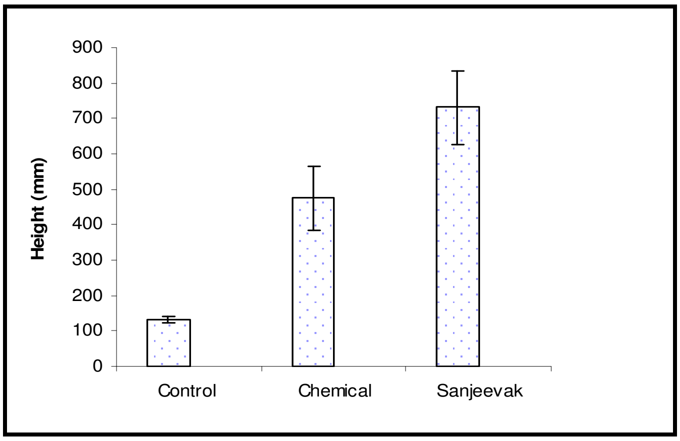

Figure 1. Effect of Sanjeevak vs. inorganic fertilizer on crop plant heights (mean ± standard error).

Table 4. Mean values of selected growth parameters of cucumber as affected by similar Sanjeevak and chemical fertilizer NPK application rate.

Treatment	Fresh biomass (g pot^{-1})		Dried biomass (g pot^{-1})		Total biomass (g pot^{-1})	
	Stems	Root	Stems	Root	Fresh	Dried
Control	13.49c	5.64b	3.09c	0.56c	19.13c	3.65c
Inorganic fertiliser	55.44b	5.78b	10.7b	1.04b	61.22b	11.74b
Sanjeevak	72.69a	13.47a	15.27a	2.43a	86.16a	17.7a

Means within each column followed by the same letter are not significantly different at $P<0.05$

Conclusions

In relation to the strictest current legislation that regulate the use of wastewater sludge for agricultural purposes, the assessment of Sanjeevak revealed that none of the heavy metals and feacal coliform levels measured exceeded permissible limits for application to cropland. In addition, the results revealed that the use of Sanjeevak can be as effective as commercial fertilizer as a source of essential nutrients for crops.

References

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