

Waste Treatment Innovation For Infusion Bottle Using Soil Solution

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Research Article

Keywords: Waste Treatment, Infuse Bottle, Soil

Posted Date: December 13th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-1133990/v1>

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Abstract

Disposal of medical or clinical waste into the environment can cause nosocomial and other environmental pollution. Treatment of medical or clinical waste requires modern technology and very high processing costs. Medical waste treatment requires innovation in processing medical waste to be easy to apply in health care facilities. For this reason, it is necessary to innovate antibacterial methods to clean bacteria. This study used an experimental design using a completely randomized design. The treatment was carried out by rinsing with sterile distilled water seven times, using 45% soil with a contact time of 2 minutes. Experiments in the study were carried out twice. The effect of treatment on decreasing the number of bacteria used a mathematical model of Multiple Linear Regression. The results show that the disinfection of infusion bottles is contaminated with bacteria. When using water only requires rinsing up to 6 times, it is sufficient to rinse only once if using a soil solution. Disinfection of infusion bottles contaminated with bacteria using soil solution was able to reduce the number of bacteria by 98%.

Introduction

The hospital as a health service facility, both outpatient and inpatient, is a place where sick people are treated, this can cause disease transmission. The government overcomes this problem with the Minister of Health of the Republic of Indonesia No. 7 of 2019 The regulation regulates hospital environmental health, one of which is environmental health requirements for decontamination through sterilization(Permenkes RI 2019). Disinfection is an effort to reduce or eliminate the number of disease-causing pathogenic microorganisms (excluding spores) by physical and chemical means. While sterilization is an effort to eliminate all microorganisms by physical and chemical means, one of the requirements for the density of floor and wall germs at the end of the disinfection process is 0 CFU/cm² to 5 CFU/cm².

A large number of medical waste that causes complex problems is the high cost of processing clinical waste. Legislation requires medical or clinical waste to be processed not to cause nosocomial and other environmental pollution. Treatment of medical or clinical waste requires more sophisticated technology and very high processing costs. Medical waste treatment requires innovation in processing medical waste so that it is easy to apply in health care facilities(Irfa'i et al. 2020).

Previous research by Marsum, et.al to reduce the number of pathogenic bacteria *Bacillus cereus* contained in syringe solid waste by using several techniques, including autoclave sterilization with a temperature of 121⁰C for 15 minutes, andesol soil 45% or with a combination of the two methods to increase potency sterilization of medical waste is proven to be effective(Marsum et al. 2020).

The antimicrobial activity of clay nanocomposites tested against bacterial strains of *S. aureus*, *Enterobacter faecalis*, *Pseudomonas aeruginosa*, and *E. coli* found that the antibacterial activity depends on pH and the clay matrix.(Holešová et al. 2021) The role of positive divalent and trivalent cations, including iron and aluminum, in the inhibition of bacteria with low pH(Behroozian et al. 2020).

In the teachings of Islam, to clean unclean dirt, including bacteria on the body, it is washed seven times, one of which is mixed with soil. The preliminary test to clean the infusion bottle contaminated with bacteria with dry soil still leaves some bacteria, while cleaning the bacteria with water alone must be done repeatedly. For this reason, in this study, mixing water with soil was carried out to increase the effectiveness of cleaning bacteria in infusion bottles.

Method

This study used experimental design using a completely randomized design by taking samples from Tugurejo Hospital Semarang. It is conditioned in a particular storage room to stabilize the number of bacteria in the infusion bottle. The treatment was focused on the effectiveness of rinsing water and soil to determine the decrease in the number of pre and post-bacteria in-hospital infusion bottle waste. The treatment was carried out by rinsing with sterile Aquades 7 times, one of which was using 45% soil with a contact time of 2 minutes. The number of repetitions in the treatment of this study was calculated using the Federer formula approach, with the result of 2 repetitions. Implementation of the treatment by swabs evenly on the infusion bottle area of 5 cm x 5 cm, bacterial culture using the spread plate method, reporting results in units of CFU/cm². The effect of treatment on decreasing the number of bacteria used a mathematical model of Multiple Linear Regression.

Results And Discussion

Baseline of Bacteria Count Data on RS Infusion Bottles

The hospital as a health service facility, both outpatient and inpatient, is a place where sick people are treated, this can cause disease transmission. The government overcomes these problems with the Minister of Health of the Republic of Indonesia no. 7 of 2019 The regulation regulates hospital environmental health, one of which is Environmental Health Requirements for Decontamination through Sterilization. Disinfection is an effort to reduce or eliminate the number of disease-causing pathogenic microorganisms (excluding spores) by physical and chemical means.¹ While sterilization is an effort to eliminate all microorganisms by physical and chemical means, one of the requirements for the density of floor and wall germs at the end of the disinfection process 0 CFU/cm² to 5 CFU/cm². According to Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning Implementation of Environmental Protection and Management, infectious waste is solid medical waste contaminated with pathogenic organisms that are not routinely present in the environment. These organisms are insufficient quantities and virulence to transmit disease to susceptible humans.(Pemerintah 2021) This study seeks to reduce or eliminate bacteria in hospital infusion bottle waste before being processed into materials that can be reused. The first step in calculating the number of bacteria in the infusion bottle waste in the hospital is done using the swab method. The measurement of the number of bacteria in the infusion bottle waste was an average of 21.4 CFU/cm² (± 2.6), with a minimum number of 16.0 CFU/ml² and a maximum of 24.0 CFU/ml². This waste needs to be managed so that it does not hurt health workers and

patients in hospitals. Waste treatment before being used can use several techniques, including autoclave sterilization with a temperature of 121⁰C for 15 minutes, 45% andesol soil or a combination of the two methods to increase the sterilization power of medical waste Marsum et al.(Marsum et al. 2020) according to government regulation No. 7 of 2019 measures to reduce the amount microorganisms by sterilizing autoclave(Permenkes RI 2019), a disinfectant. Still, an environmentally friendly one is sought, one of which is the technique of stockpiling with soil.

Homogeneity of the number of bacteria according to the treatment group

To prove that in this study the number of bacteria in all treatment groups in homogeneous or comparable conditions, the One Way Anova test was carried out, the results of which are listed in Table 1.

Table 1. Baseline of Bacterial Count Data (CFU/ml²) on RS infusion bottles

		n	Mean	SD	p*
Rinsing using soil	flushing 1	2	22.0	2.83	0.571
	flushing 2	2	22.0	2.83	
	flushing 3	2	22.0	2.83	
	flushing 4	2	22.0	2.83	
	flushing 5	2	22.0	2.83	
	flushing 6	2	22.0	2.83	
	flushing 7	2	22.0	2.83	
	control	2	22.0	2.83	

**One Way Anova*

Table 1 illustrates that samples of infusion bottle waste in hospitals were contaminated with bacteria with homogeneous or comparable amounts for all treatment groups (p=0.571). This situation provides information that researchers looking at the effect of treatment on the number of bacteria do not need to control the number of bacteria pre through multivariate analysis. However, to prove the effect of treatment on the number of bacteria, the pre-variable control was carried out to obtain a net effect of the treatment.

Decreased Bacterial Count Due to Frequency of Rinsing with Water

The results of this study indicate that the infusion bottle is contaminated with bacteria when it is only washed with water with a frequency of many times, as shown in Table 2.

Table 2
Decrease in the number of bacteria due to the frequency of rinsing with water

Treatment with a mixture of water and soil	n	Number of bacterial colonies (CFU/ml ²)	
		Mean	SD
Before rinsed	16	22.0	2.83
First rinse	16	13.7	1.89
Second rinse	16	7.0	1.41
Third rinse	16	4.5	1.41
Fourth rinse	16	1.3	0.94
Fifth rinse	16	0.5	0.71
Sixth rinse	16	0.0	0.00
Seventh rinse	16	0.0	0.00

Table 2 shows that to clean hospital infusion bottles from bacterial contamination, using water requires rinsing up to 6 times, while rinsing with water and soil only requires rinsing once.

Health care waste consists of waste generated by health facilities, medical laboratories, and biomedical research facilities. Improper treatment of this waste poses a severe risk of disease transmission to waste workers, health workers, patients, and the general public through exposure to infectious agents. Poor waste management produces hazardous and infectious contaminants to the community. Contamination of highly infectious agents such as the COVID-19 virus has created enormous instability in the handling of healthcare and recycling waste due to the volume of waste generated and its contagious nature.

Proper management of healthcare waste can add value by reducing the spread of the COVID-19 virus and increasing the recycling of materials rather than sending them to landfills. Disinfection and segregation of health care waste facilitates sustainable management and enables its use for valuable purposes.(Das et al. 2021)

The amount of medical waste that causes complex problems is the high processing cost. Legislation requires medical or clinical waste to be processed not to cause nosocomial and other environmental pollution. Treatment of medical or clinical waste requires more technology and very high processing costs. Medical waste treatment requires innovation in processing medical waste to be easy to apply in health care facilities.(Irfa'i et al. 2020)

Natural clay and rice husk modified with Na₂CO₃ are used to produce clay aggregate adsorbents for disinfection of E. Coli in water.(Ihekwe me et al. 2021) The use of clay and its PCH material can be a suitable method for removing Salmonella from water. The large adsorption capacity of Salmonella

started from the lowest value in the mont-PCH sample (0.29×10^{10} CFU g⁻¹) to the highest value in the natural palygorskite sample (1.52×10^{10} CFU g⁻¹). (Pardo et al. 2020)

Effect Of Soil Solution On Reducing Bacterial Count

The ability of the soil both physically and chemically to cause the death of bacteria. One of the mechanisms by which soil kills bacteria is by using the minerals contained in it. Minerals contained in clay such as silicate tetrahedral (SiO_4) and octahedra (consisting of Al, Mg, and Fe) are building blocks of minerals that can exchange cations and release cations metals that encourage antibacterial reactions(Williams 2019). Minerals Natural clay has antibacterial properties, one of which is based on reduced iron (Fe^{2+}). Fe^{2+} ions can enter the protein structure of bacteria's outer cells and produce hydroxyl radicals that kill bacteria.(Williams et al. 2011) The presence of other transition metals and Al^{3+} carried by natural clay also plays a direct role in this antibacterial property.(Otto et al. 2016) Clay minerals also act as a support for metals which are known to be very active as antibacterials.(Williams and Haydel 2010) Soil can absorb ions that are close to the active soil material (miscellaneous). This sorption ability decreases as the radius increases. In other words, the more concentrated the concentration of the soil solution has the tighter space and causes a large sorption capacity. This binding/absorbing ability decreases with low water content; this is due to the ability of the micelles to be active properly when the soil is in a solution or aqueous condition.(Hardjowigeno 2010)

Cleaning or reducing the number of bacteria in infusion bottle waste is a reasonable effort before the process is utilized in other products. In this study, rinse the infusion bottle waste repeatedly with various treatments. The effect of decreasing the number of bacteria varies according to the type of treatment given, which can be seen in Figure 1.

Figure 1 shows that initially, all treatment groups had the same number of bacteria, which was 21.4; After being given various treatments, the position of groundwater rinsed, in any position when rinsed with groundwater was able to clean the bacterial contamination of the infusion bottle waste. The decrease in the number of bacteria effects from the treatment after being analyzed using a linear regression mathematical model which was controlled through analysis by the number of pre bacteria resulted in a number of differences in the number of bacteria for each treatment compared to the control group as shown by the regression coefficient (B), in Table 3.

Table 3. Effect of Flushing Treatment of Groundwater Mixture at Various Positions on the Decrease in Bacterial Count

	B	SE	T	p	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Treatment with a mixture of groundwater							
First rinse	-19.9	1.1	-17.9	<0.001	-22.6	-17.3	98%
Second rinse	-16.1	1.3	-12.5	<0.001	-19.1	-13.0	96%
Third rinse	-14.6	0.9	-15.3	<0.001	-16.8	-12.3	97%
Fourth rinse	-11.9	0.8	-14.5	<0.001	-13.8	-9.9	97%
Fifth rinse	-10.7	1.3	-8.4	<0.001	-13.7	-7.7	91%
Sixth rinse	-9.2	0.6	-14.6	<0.001	-10.7	-7.7	97%
Seventh rinse	-7.5	1.9	-4.0	0.005	-12.0	-3.1	69%
Control							

Based on Table 3. of the seven positions of rinsing groundwater, starting from groundwater to rinse infusion bottles contaminated with bacteria, the first rinse directly with groundwater to rinse groundwater at the seventh rinse position, can reduce the number of different bacteria and is increasingly in the backward position. the ability to reduce the number of bacteria decreases. However, in any position treatment when rinsed with ground water was able to clean the bacteria that contaminate the infusion bottle. As stated in the table, the infusion bottle contaminated with bacteria when directly washed with groundwater was able to reduce the number of bacteria by 19.9 CFU lower than the control group, and the decrease was statistically significant ($p < 0.001$). The first rinse with ground water was able to clean up 98% of bacteria. In subsequent rinses from the second to seventh treatments, the reduction of bacteria appeared to be less effective than if the water and soil treatments were carried out in the first rinse. However, the treatment in the first to seventh rinses was still proven to reduce the number of bacteria. This difference in effectiveness may be due to differences in the ability and viability of different bacteria found on the plabot. So there is a possibility that bacteria that still survive in the final rinse are more resistant to the antibacterial power of the soil. Other studies have suggested that soil and mineral content in modified soils can be used to remove pathogenic bacteria. The mechanisms that occur in this process are mainly cation exchange and ion-dipole coordination interactions and hydrogen bonds; and this process largely depends on the isoelectric point, the size of the molecule, the shape of the molecule, and the pH of the solution.(Negron-Mendoza and Ramos-Bernal 2006) Clay naturally contains minerals that can be dissolved in water. Soil pH with hydrated antibacterial properties was generally high (>10) or low (<5), where soluble Al and Fe were found. The presence of Fe and Al compounds and other transition metals has a direct role in the antibacterial properties of the soil (Londono, Hartnett, and Williams 2017; Morrison et al. 2014).

Research by Morrison et al (2014), also shows that soil kills pathogenic compounds within <24 hours with chemical toxicity that occurs, and not physically.(Morrison et al. 2014) When antibacterial soil

removed from its natural environment and activated with deionized water for medical applications, soil rebalances with new fluids. During this process, dissolved and oxidized minerals such as pyrite, plagioclase, smectite release metals that suppress the growth of pathogenic bacteria.

In Islamic jurisprudence, purification according to Islam (thaharah) the process of removing najis requires the process of rinsing using several washes of water where one of the washes is mixed with soil. Mixing soil with water will produce a mixture of solutions, colloids, and suspensions of clay and humus. Humus particles dissolved in water will produce a solution that can function as a surfactant. The combination of clay nanoparticles and surfactants has been known to have antiviral properties.(Liang et al. 2014) So it can be understood that the presence of water and soil produces a system that contains antiviral powers. While the antibacterial properties are also owned by the clay from the dissolved aluminum(Morrison, Misra, and Williams 2016).

To see the difference in the effects of the seven types of treatment after being tested using the Least Significant Different (LSD), which is indicated by the difference in mean between groups, as shown in Table 4.

Table 4
Differences in the Decrease in the Number of Bacteria between Treatments

Treatments		Mean difference	SE	p	95% Confidence Interval For Difference	
					Lower Bound	Upper Bound
First rinse soil	Second rinse soil	-1.75	0.67	0.035	-3.34	-0.16
	Third rinse soil	-2.38	0.67	0.010	-3.97	-0.79
	Fourth rinse soil	-2.63	0.67	0.006	-4.22	-1.04
	Fifth rinse soil	-3.50	0.67	0.001	-5.09	-1.91
	Sixth rinse soil	-3.63	0.67	0.001	-5.22	-2.04
	Seventh rinse soil	-3.63	0.67	0.001	-5.22	-2.04
	Control	-11.22	0.81	0.000	-13.13	-9.32
Second rinse soil	Third rinse soil	-0.63	0.67	0.0384	-2.22	0.97
	Fourth rinse soil	-0.88	0.67	0.234	-2.47	0.72
	Fifth rinse soil	-1.75	0.67	0.035	-3.34	-0.16
	Sixth rinse soil	-1.88	0.67	0.027	-3.47	-0.29
	Seventh rinse soil	-1.88	0.67	0.027	-3.47	-0.29
	Control	-9.47	0.81	0.000	-11.38	-7.57
Third rinse soil	Fourth rinse soil	-0.25	0.67	0.721	-1.84	1.34
	Fifth rinse soil	-1.13	0.67	0.138	-2.72	0.47
	Sixth rinse soil	-1.25	0.67	0.105	-2.84	0.34
	Seventh rinse soil	-1.25	0.67	0.105	-2.84	0.34
	Control	-8.85	0.81	0.000	-10.75	-6.95
Fourth rinse soil	Fifth rinse soil	-0.88	0.67	0.234	-2.47	0.72
	Sixth rinse soil	-1.00	0.67	0.181	-2.59	0.59

Treatments		Mean difference	SE	p	95% Confidence Interval For Difference	
					Lower Bound	Upper Bound
	Seventh rinse soil	-1.00	0.67	0.181	-2.59	0.59
	Control	-8.599	0.80	0.000	-10.50	-6.70
Fifth rinse soil	Sixth rinse soil	-0.13	0.67	0.858	-1.72	1.47
	Seventh rinse soil	-0.13	0.67	0.858	-1.72	1.47
	Control	-7.72	0.81	0.000	-9.63	-5.82
Sixth rinse soil	Seventh rinse soil	-0.00	0.67	1.000	-1.59	-1.59
	Control	-7.60	0.81	0.000	-9.50	-5.70
Seventh rinse soil	Control	-7.60	0.81	0.000	-9.50	-5.70

Table 4 illustrates that rinsing the infusion bottle contaminated with bacteria directly with groundwater is better than rinsing in the second position and so on ($p=0.035$). The difference in the decrease in the number of bacteria was 11.2 compared to the control group.

The hospital as a health service place that serves inpatient and outpatient services in service activities produces medical waste. which is a group of hazardous and toxic waste in health service activities. To maintain the hospital environment. it's regulated by the Regulation of the Minister of Health of the Republic of Indonesia No. 7 of 2019 concerning hospital environmental health. while the handling of hazardous and toxic waste is regulated by government regulation No. 22 of 2021 concerning environmental management. Referring to the regulation. the researcher is committed to managing B3 waste. especially infusion bottles. so that they can be reprocessed. one of the efforts is to reduce or eliminate bacteria that contaminate infusion bottles (Permenkes RI 2019; Pemerintah 2021).

Maharani et al (2017) grouped medical hazardous and toxic waste at Soedirman Semarang Hospital including syringes. disposable masks. disposable gloves. infusion bottles. scalpels. contaminated cotton. contaminated gauze. medicine bottles. scalpel infusion hoses (Maharani. Joko. and Dangiran 2017). Elsewhere. Panembahan Senopati Bantul Hospital. Infusion bottles and jerry cans go through a processing process by the hospital. namely emptying. cleaning. disinfection. counting. and packaging. Furthermore. the packaged waste is submitted to CV. Timdis to be handed over to a plastic processor. namely Fila Djaya Plasindo. then the hospital will get income in the form of plastic baggies of yellow and black garbage containers according to the hospital's request (Madjeed 2020; Setyawati 2020).

The technology for removing hazardous waste is incineration. The incineration system can reduce the volume of medical waste by up to 99.95%. In addition, incineration technology can digest medical waste materials that are harmful to the environment and destroy pathogenic bacteria. However, the incineration system has its drawbacks. One disadvantage is that it produces residual ash and waste that still contains heavy metals. Therefore, improvement in incineration management is needed. One of the efforts that can be done is the treatment of residues and ash waste.(Sutrisno and Meilasari 2020)

According to Marsum et al (2020), waste treatment before being used can use several techniques including autoclave sterilization with a temperature of 121°C for 15 minutes, 45% andosol soil with a contact time of 2 minutes or a combination of the two methods to increase the sterilization power of medical waste(Marsum et al. 2020).

Clay (andosol) which is very abundant can be used as an anti-bacterial by applying tubular SiO₂-NT @ Cu nanocomposites that can inhibit the growth of E. coli and S. aureus effectively with minimal inhibitory concentrations (MIC) of 2.0 mg/mL and 0.6mg/mL(Dong et al. 2020).

The antimicrobial activity of clay nanocomposites tested against bacterial strains of S. Aureus, E. Faecalis, P. Aeruginosa, and E. Coli, was then evaluated by finding the minimum inhibitory concentration. It was found that the antibacterial activity depends on the pH and also on the clay matrix(Holešová et al. 2021). The role of divalent and trivalent positive cations, including iron and aluminum in the inhibition of bacteria with low pH(Behroozian et al. 2020).

Conclusion

Disinfection of infusion bottles using a mixture of water and soil is more effective than using water without a mixture of soil. The effectiveness of the disinfection of a mixture of water and soil reaches 98% in the first month.

Declarations

Ethical Approval. Not applicable

Consent to Participate. Not applicable

Consent for publication. Not applicable

Data availability. All data generated or analysed during this study are included in this published article.

Funding. The research used budget funds the Poltekkes Kemenkes Semarang

Competing Interests. The authors declare that there is no conflict of interest regarding the publication of this manuscript.

Authors' contributions. All the authors collaborated in this work. Marsum conceptualized the study; Marsum, Sunarto, Widodo, designed methodologies; Marsum, and Khayan performed formal analysis; Marsum, Slamet Wardoyo wrote and prepared the original draft; and Marsum, and Slamet Wardoyo wrote, edited, and reviewed the article.

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Figures

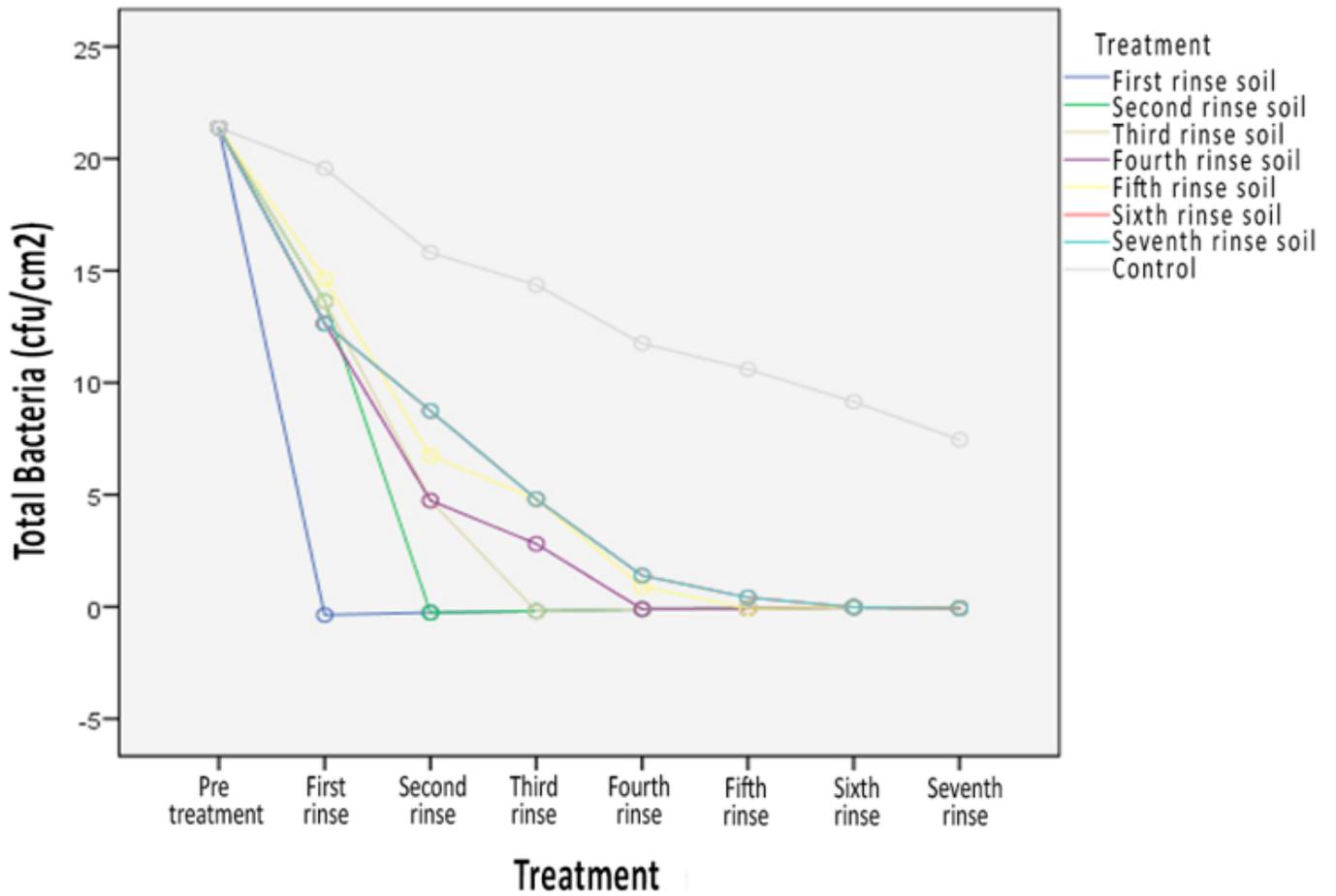


Figure 1

Changes in the decrease in the number of bacteria between the treatment group and the control group