IC-007
Effect of Sound Frequency on Soil Microbial Activity and Organic Matter Decomposition Rate

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ABSTRACT

This is an efficacy experiment of sound frequencies on soil microbes and decomposition. Soil samples were collected with organic additions received 432 Hz, 528 Hz, 1000 Hz, and control (no sound treatment) as treatment for one week of no exposure followed by another with proper exposure. The efficacy of sound treatment was measured by weight loss of the organic matters added.

A conclusion will be made based upon the results relative to treatment pH, decomposition rates, and other external alterations. The result section contained spreadsheets and graphs for sound treatment comparison. Soil microbial activity was successfully impacted by sound treatment. The results indicated that sound frequency influenced microbial activity, with 432 Hz producing the most significant decomposition.

Keywords: Decomposition Rate, Microbial Activity, Frequencies

Introduction

The relationship between sound waves and microbial activity plays a role in complex biophysical mechanisms, potentially affecting microbial metabolism and growth. Vibrations from sound waves can cause microstreaming and relieve stress on cellular membranes, which may alter membrane permeability, metabolic pathways, and stimulate biofilm formation. According to Pornpongmetta et al., aerobic bacteria from wastewater are affected by music. Similarly, Wang Xiujuan et al. claimed that sound waves influence nucleic acid and protein synthesis, accelerating organic matter decomposition.

In this experiment, we aim to investigate whether different sound frequencies affect microbial activity in soil. Specifically, we explore if certain frequencies can enhance microbial processes, leading to faster decomposition, improved pH balance, and better plant growth. Sounds are vibrations that travel through a medium, such as air. These vibrations vary in frequency, measured in hertz (Hz), which determines the pitch—low frequencies produce deeper tones, while high frequencies produce higher-pitched sounds. These frequencies carry energy that can interact with physical systems, including biological matter such as cells and microorganisms. Research has shown that specific sound frequencies may influence microbial processes through changes in membrane permeability, metabolic activity, and biofilm formation.

Microbial activity refers to processes carried out by microorganisms like bacteria and fungi, essential for breaking down organic matter, recycling nutrients, and maintaining soil health. Factors such as temperature, moisture, pH, and potentially sound waves affect these activities. Understanding how to stimulate microbial activity could lead to improved soil management and agricultural productivity. Decomposition, the breakdown of dead organic matter by microorganisms, plays a key role in returning nutrients to the soil. This process supports nutrient cycling and plant growth. Enhancing microbial activity and decomposition through sound could improve soil quality and crop yield.

This study aims to explore whether sound frequencies can influence microbial activity and decomposition rates. If certain frequencies can stimulate microbial processes, this approach could offer innovative strategies to improve soil health, reduce dependency on chemical fertilizers, and support sustainable agriculture.

Purposes

1) To explore whether sound frequencies can influence soil microbial activity and decomposition rates
2) To put further applications in the development of agriculture

Research Methodology

1. Prepare 12 pots of soil with the same type (general-purpose garden soil) and 150g of soil (3 for each frequency for a total of 4)
2. Measure the pH of the initial soil samples before (1:2 soil to tap water stir and let settle. Then Dip the pH test strip into the liquid, read and compare with color scale) by separating it into 3 cups randomly 5g each and measure 3 times in all those cups using pH strips.
3. Grind and add 15 grams of organic matter (Asystasia gangetica T. Anders) and separate all the pots at this same amount in grams
4. Add 20 mL of water and mix thoroughly
5. Cover the cup with plastic wrap to minimize mass loss from evaporation.
6. Weigh the mass of the entire cup including all the components
7. Leave it for a week to start decomposing first
8. After a week of decomposition, expose a specific different sound frequency for another 1 full week about 60 dB or 90% max phone volume at a distance of 5 cm.
9. Cover it with a container cylindrical shape to maximize all echos (Diameter of 21 cm and height of 28 cm) with a towel on the bottom to further minimize sound escaping
10. Record the data by weighing the cup afterward and recording the mass change relative to the organic matter added (15 g) since the only mass that can change is from decomposing.

Soil temperature, pH, and duration of sound exposure were uniformly maintained to minimize their potential confounding effects. To reduce potential confounding factors from soil microbial composition, all soil samples were collected from a single area.

Results

Measurement Before

pH strip	Sample 1	Sample 2	Sample 3
1	3	3.5	3.5
2	3.5	3.5	3
3	3.5	4	3
Avg	3.33	3.67	3.17
Total avg			3.39

*We mixed the soil thoroughly and measured the pH before separating it into other cups

Experiment at a frequency of 528 Hz

528 Hz	Cup 1	Cup 2	Cup 3
Soil + Cup weight	150 g	150 g	150 g
Water	20.07 g	20.09 g	20.11 g
Leaves	15 g	15 g	15 g
Plastic Wrap	1.47 g	1.74 g	2.04 g
Total	186.54 g	186.83 g	187.15 g
Weight exclude warp	185.07 g	185.09 g	185.11 g

Experiment at a frequency of 250 Hz

250 Hz	**Cup 1**	**Cup 2**	**Cup 3**
Soil + Cup weight	150 g	150 g	150 g
Water	20.24 g	20.12 g	20 g
Leaves	15 g	15 g	15 g
Plastic Wrap	1.38 g	1.53 g	1.89 g
Total	186.62 g	186.65 g	186.89 g
Weight exclude warp	185.24 g	184.12 g	185 g

Experiment at a frequency of 432 Hz

432 Hz	**Cup 1**	**Cup 2**	**Cup 3**
Soil + Cup weight	150 g	150 g	150 g
Water	20 g	20.05 g	20.15 g
Leaves	15 g	15 g	15.06 g
Plastic Wrap	1.55 g	1.62 g	1.43 g
Total	186.55 g	186.67 g	186.64 g
Weight exclude warp	185 g	185.05 g	185.21 g

Summary of material weights in each experimental cup

Control	**Cup 1**	**Cup 2**	**Cup 3**
Soil + Cup weight	150	150	150
Water	20.1	20	20.03
Leaves	15	15.02	15
Plastic Wrap	1.72	1.7	1.64
Total	186.82	186.72	186.67
Weight exclude warp	185.1	185.02	185.03

Summary of weight change and organic matter decomposition (%) under 528 Hz

528 Hz (pH was 6 after 2 weeks)		Change		Change		Change	Avg
Weight	**Cup 1**		**Cup 2**		**Cup 3**		
Initial	186.54 g		186.83 g		187.15 g		
Week 1	182.17 g	- 4.37 g	182.76 g	- 4.07 g	182.78 g	- 4.37 g	- 4.27 g
After frequency	178.35 g	- 3.82 g	179.34 g	- 3.42 g	179.29 g	- 3.49 g	- 3.58 g
		%		%		%	
A	**Week 1**	- 29.13		- 27.13		- 29.13	- 28.46
B	**After frequency**	- 35.94		- 31.29		- 32.83	- 33.35

- **A** - Percentage of organic matter mass loss relative to the previous weighing / after 1 week of decomposition without frequency. (Mass change from the week before, only assuming all came from organic matter, Mass change / 15 (organic matter initial mass) ex. This week mass changed by - 4.37 g / 15 = 29.13 %)
- **B** - Percentage of organic matter mass loss relative to the previous weighing / after 2nd week of decomposition with frequency. (Mass change from the week before, only assuming all came from organic matter, Mass change / (organic matter after 1 week mass) ex. After frequency week mass changed by - 3.82 g / 15 - 4.37 (the change from the week before) = 35.94 %)

Summary of weight change and organic matter decomposition (%) under 250 Hz

250 Hz (pH was 6 after 2 weeks)		Change		Change		Change	Avg
Weight	**Cup 1**		**Cup 2**		**Cup 3**		
Initial	186.62 g		186.65 g		186.89 g		
Week 1	182.55 g	- 4.07 g	182.46 g	- 4.19 g	182.37 g	- 4.52 g	- 4.26 g
After frequency	179.72 g	- 2.83 g	178.99 g	- 3.47 g	178 g	- 4.37 g	- 3.56 g
		%		%		%	
A	**Week 1**	- 27.13		- 27.93		30.13	- 28.40
B	**After frequency**	- 25.89		- 32.10		41.70	- 33.23

- **A** - Percentage of organic matter mass loss relative to the previous weighing / after 1 week of decomposition without frequency.
- **B** - Percentage of organic matter mass loss relative to the previous weighing / after 2nd week of decomposition with frequency.

Summary of weight change and organic matter decomposition (%) under 432 Hz

432 Hz (pH was 5.5 after 2 weeks)		Change		Change		Change	Avg
Weight	**Cup 1**		**Cup 2**		**Cup 3**		
Initial	186.55 g		186.67 g		186.64 g		
Week 1	182.73 g	- 3.82 g	182.61 g	- 4.06 g	183.72 g	- 2.92 g	- 3.60 g
After frequency	178.35 g	- 4.38 g	178.48 g	- 4.13 g	179.58 g	- 4.14 g	- 4.22 g
		%		%		%	
A	**Week 1**	- 25.47		- 27.07		- 19.47	- 24.00
B	**After frequency**	- 39.18		- 37.75		- 34.27	- 37.07

- A - Percentage of organic matter mass loss relative to the previous weighing / after 1 week of decomposition without frequency.
- B - Percentage of organic matter mass loss relative to the previous weighing / after 2nd week of decomposition with frequency.

Summary of weight change and organic matter decomposition(%) in each cup under 528 Hz

Control (pH was 6 after 2 weeks)		Change		Change		Change	Avg
Weight	**Cup 1**		**Cup 2**		**Cup 3**		
Initial	186.82 g		186.72 g		186.67 g		
Week 1	182.54 g	4.28 g	183.05 g	3.67 g	182.44 g	4.23 g	4.06 g
Week 2	179.33 g	3.21 g	180.00 g	3.05 g	179.40 g	3.04 g	3.10 g
		%		%		%	
A	**Initial**	28.53		24.43		28.20	27.06
B	**Week 1**	29.94		26.87		28.23	28.35

- A - Percentage of organic matter mass loss relative to the previous weighing / after 1 week of decomposition without frequency.
- B - Percentage of organic matter mass loss relative to the previous weighing / after 2nd week of decomposition with frequency.

Summary of weight change and organic matter decomposition(%) in each cup under 250 Hz

Control (pH was 6 after 2 weeks)		Change		Change		Change	Avg
Weight	**Cup 1**		**Cup 2**		**Cup 3**		
Initial	186.62 g		186.65 g		186.89 g		
Week 1	182.55 g	4.07 g	182.46 g	4.19 g	182.37 g	4.52 g	4.26 g
Week 2	179.72 g	2.83 g	178.99 g	3.47 g	178.00 g	4.37 g	3.56 g
		%		%		%	
A	**Initial**	27.13		27.93		30.13	28.40
B	**Week 1**	25.89		32.10		41.70	33.23

- A - Percentage of organic matter mass loss relative to the previous weighing / after 1 week of decomposition without frequency.
- B - Percentage of organic matter mass loss relative to the previous weighing / after 2nd week of decomposition with frequency.

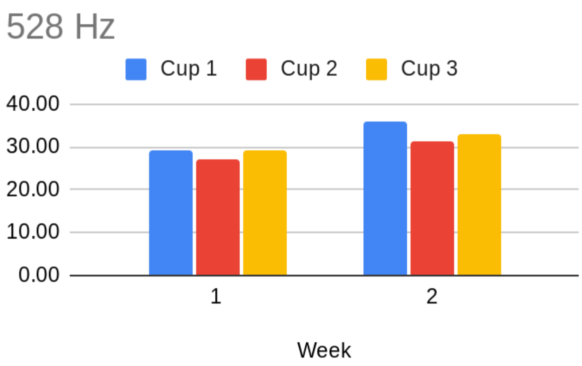
Summary of weight change and organic matter decomposition(%) in each cup under 432 Hz

Control (pH was 5.5 after 2 weeks)		Change		Change		Change	Avg
Weight	**Cup 1**		**Cup 2**		**Cup 3**		
Initial	186.65 g		186.67 g		186.64 g		
Week 1	182.73 g	3.82 g	182.61 g	4.06 g	183.72 g	2.93 g	3.60 g
Week 2	178.35 g	4.38 g	178.48 g	4.13 g	179.58 g	4.14 g	4.22 g
		%		%		%	
A	**Initial**	25.47		27.07		19.477	24.00
B	**Week 1**	39.18		37.75		34.27	37.07

- A - Percentage of organic matter mass loss relative to the previous weighing / after 1 week of decomposition without frequency.
- B - Percentage of organic matter mass loss relative to the previous weighing / after 2nd week of decomposition with frequency.

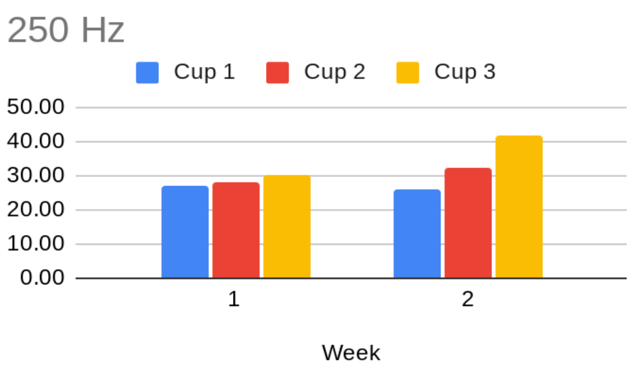
Graph of experiment at a frequency of 528 Hz

528 Hz	Change in percent		
Week	Cup 1	Cup 2	Cup 3
1	29.13	27.13	29.13
2	35.94	31.29	32.83



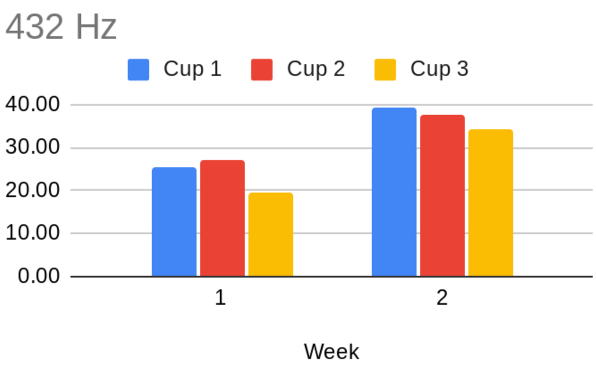
Graph of experiment at a frequency of 250 Hz

250 Hz	Change in percent		
Week	Cup 1	Cup 2	Cup 3
1	27.13	27.93	30.13
2	25.89	32.10	41.70



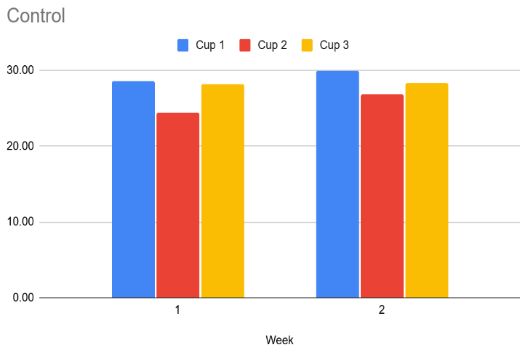
Graph of experiment at a frequency of 432 Hz

432 Hz	Change in percent		
Week	Cup 1	Cup 2	Cup 3
1	25.47	27.07	19.47
2	39.18	37.75	34.27



Graph summary of material weights in each experimental cup

Control			
Week	Cup 1	Cup 2	Cup 3
1	28.53	24.43	28.20
2	29.94	26.87	28.23



ANOVA Statistical analysis

Group	Source	SS	df	MS	F-value	p-value	Significance
528Hz	Cup	15.33	2	7.67	1.53	0.34	ns
528Hz	Week	56.02	1	56.02	12.80	0.04	*
528Hz	Interaction	2.69	2	1.35	0.31	0.75	ns
432Hz	Cup	112.47	2	56.24	4.21	0.07	ns
432Hz	Week	320.18	1	320.18	89.62	0.00	**
432Hz	Interaction	1.39	2	0.70	0.26	0.78	ns
250Hz	Cup	124.82	2	62.41	3.12	0.12	ns
250Hz	Week	128.41	1	128.41	11.07	0.05	*
250Hz	Interaction	8.16	2	4.08	1.02	0.45	ns
Control	Cup	6.67	2	3.33	0.33	0.73	ns
Control	Week	5.04	1	5.04	2.67	0.20	ns
Control	Interaction	0.10	2	0.05	0.05	0.95	ns

Post hoc statistical analysis

Group	Comparison	Mean Difference	p-value	Significance
432Hz Post-Hoc	Cup1 vs Cup2	2.13	0.65	ns
432Hz Post-Hoc	Cup1 vs Cup3	8.29	0.09	ns
432Hz Post-Hoc	Cup2 vs Cup3	6.16	0.17	ns
250Hz Post-Hoc	Cup1 vs Cup2	-4.21	0.23	ns
250Hz Post-Hoc	Cup1 vs Cup3	-14.81	0.01	*
250Hz Post-Hoc	Cup2 vs Cup3	-10.60	0.04	*

Statistical analysis summary

1. 528Hz Group:

- The week showed a significant effect ($F = 12.8$, $p = 0.04$*)
- Cup and Interaction were non-significant ($p > 0.05$)

2. 432Hz Group:

- The week showed a highly significant effect ($F = 89.62$, $p = 0.002$**)
- Cup showed marginal significance ($F = 4.21$, $p = 0.07$)
- Interaction was non-significant

3. 250Hz Group:

- The week showed a significant effect ($F = 11.07$, $p = 0.05$*)
- Cup showed a non-significant effect ($F = 3.12$, $p = 0.12$)
- Interaction was non-significant

4. Control Group:

- No significant effects found (all $p > 0.05$)

Post-Hoc Analysis:

1. 432HzGroup:

- No significant differences between any cup pairs (all $p > 0.05$)

2. 250HzGroup:

Significant differences found:

- Cup 1 vs Cup 3 (Mean Different = -14.81 , $p = 0.01$*)

- Cup2 vs Cup3 (Mean Different = -10.6 , $p = 0.04$*)

Key Findings:

- Time (Week) was the most influential factor across multiple groups
- Only 250Hz showed significant cup-to-cup differences in post-hoc tests
- No significant interaction effects were found in any group

Note: *$p < 0.05$, ** $p < 0.01$, ns = not significant

Discussion

The experiment shows microorganism stimulation and therefore decomposition through various sound frequencies (432, 528, 250, and 0Hz/control). Measurement of effectiveness came through mass loss. For the first week where the decomposition happens without the frequency, the rate is about 25 % to 30 % but after a week of exposure, most of it increases to 30 % to 35 %. Ultimately, however, 432 Hz had the greatest weight loss at 4.22 g, 528 showed 3.58 g, and 250 Hz showed 3.56 g, which supports that 432 Hz is the most effective frequency to encourage microorganism stimulation and thus rapid decomposition, while one without exposure maintained a noticeable composition rate seen by the mass change in percent each week throughout the experiment. Regarding pH, it changed throughout the course as anticipated, from an initial acidic pH of ~3.39 to a more neutral range commonly associated with effective microorganism stimulation later all measured in a range of 5 - 6 which is in an ideal range. However, because pH results are inconclusive since those were relatively the same, this information may not be pertinent to the expected outcome. But in terms of frequency applied to each group, 432 Hz did have the most stimulation for microorganism activity both by mass and percent, while 528, 250, and control gave less active rates of decomposition.

Although efforts were made to control soil conditions, light exposure and micro-vibrations from the equipment may have influenced microbial activity

Conclusions

This experiment was successful in concluding that sound frequencies affect soil microbial activity and resultant decomposition. Specifically, this study's results determined that exposure to sound frequencies—more specifically, 432 Hz—resulted in the greatest amount of decomposition relative to organic matter weight loss. Thus, exposure to certain sound frequencies increases microbial activity and thus more successful decomposition.

Yet assessing which sound frequencies worked best for pH was difficult as well since pH was nearly neutral and all the control group's changes were relatively stable. However, the fact that microbial activity increased and decomposition increased suggests that sound treatment would be beneficial for soil amendments.

These findings confirm the potential of sound frequencies at an elevated level to help, yet replication and research toward long-term application for agricultural practicality are necessary. Future experiments could include longer hours of exposure and a wider variety of frequencies on different types of soil. Thus, if sound can be perfected, it presents an organic approach to improving soils and preventing chemical fertilizers for more eco-friendly agricultural intentions.

Practical Implications for Sustainable Agriculture

- Improving soil quality and characteristics without Chemicals

if sound frequency proves to affect microbial metabolism and growth this could serve as a method for improving soil quality without using chemicals. Enhancing it through non-chemical methods may restore soil fertility in a more environmentally friendly and sustainable way.

- Acceleration of Organic Decomposition

Sound frequency could lead to faster nutrient and more efficient nutrient cycling. This could reduce the time required for compost maturation and improve soil nutrient availability. This may reduce reliance on synthetic fertilizers, lowering costs and minimizing nutrient loss.

- Non-invasive & Eco-friendly method

Using sound frequency it's a non-invasive method by not contaminate the soil or leaving a chemical residue. This makes it an eco-friendly alternative for improving soil quality and soil functions while maintaining biodiversity and upholding ecological integrity.

Recommendations

This experiment demonstrated that sound frequencies influence soil microbial activity and decomposition rate. The results showed that 432 Hz had the highest decomposition rate among all the frequencies tested which supports the hypothesis that specific frequencies can potentially enhance microbial activity.

Strengths:
- Time management after some tweaks on the initial methodology.
- Clear methodology with measurable outcomes (mass loss and pH changes).
- Practical applications in agriculture for improving soil health naturally.

Limitations:
- pH changes were inconclusive as all samples reached a similar range.
- A short duration of only 2 weeks due to time limitation, a longer time could result in more accurate data.
- Limited frequency range - testing additional frequencies could result in clearer conclusions.
- The methodology before experimenting was unclear, resulting in a delayed finish date.
- Variables can't be controlled to an extent due to a lack of resources

Suggestions :
- suggest further investigation of molecular or cellular mechanisms of sound frequency test

Future improvements include testing and experimenting for longer, testing other types of organic matter, and better control on variables.

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