Integrated Innovation of Saponin Extraction from Rain Tree Pods for Odor Control Products in Animal Facilities

Boriwut Jiramongkhonrat[1], Wan wiriya[1,2,3], Rateeya Saikaew[1,2,3]
[1]Department of Chemistry Faculty of Scien, Chiang Mai University. Chiang Mai, Thailand
[2]Enviromental Chemistry Research Laboratory, Chiang Mai University. Chiang Mai, Thailand
[3]Enviromental Science Reseach Center, Chiang Mai University. Chiang Mai, Thailand



Abstract

This study develops a method to extract saponins from rain tree pods (Samanea saman) for use as an active ingredient in odor and VOCs control products. The formulation is specifically designed for both livestock farms and household pet environments. The process utilizes Pulsed Electric Field (PEF) extraction and yeast fermentation to create a natural solvent-based extract. Analysis confirmed a total saponin content of 40,301.9 mg/L with 98.18% accuracy using the Vanillin-Sulfuric Acid Spectrophotometric Assay. Field testing using an FTIR gas analyzer showed significant air quality improvements. The spray application achieved a 100% reduction of Acrylonitrile (from 21.55 mg/m^3), while removing 81.52% of ammonia and 80.03% of BTEX. When used with porous glass beads, ammonia and BTEX removal reached 100% and 95%, respectively. Consequently, the Hazard Index (HI) dropped from 36,387.83 to 1,812.92. This study demonstrates a sustainable approach to upcycling agricultural waste into high-efficiency air purification solutions, contributing to a circular economy through innovative waste management. The project aims to expand this technology into the livestock and pet care sectors, providing natural, high-performance filtration that enhances air quality while maintaining an eco-friendly product profile.

Introduction

Livestock farms and animal owners frequently encounter air pollution issues caused by ammonia gas ammonia and volatile organic compounds (VOCs), which adversely affect the health of both animals and humans. Currently, the use of chemical deodorizers incurs high costs and may leave harmful residues. Meanwhile, in Thailand, a vast amount of fallen rain tree pods is discarded as agricultural waste. Studies have shown that rain tree pods are highly rich in saponins (Saponins), which exhibit biosurfactant properties capable of trapping ammonia gas and VOCs. Therefore, this research aims to utilize these waste rain tree pods through an extraction process to develop an innovative, safe, and eco-friendly bio-deodorizing solution.

Objective

1. **To extract saponins from rain tree pods utilizing a biological process combined with Pulsed Electric Field (PEF) technology.**
2. **To develop an effective, safe, and eco-friendly deodorizing solution capable of eliminating odors and VOCs for application in both livestock farms and indoor environments.**
3. **To create a low-cost product prototype that can be practically produced and utilized at the community level.**

Methodology

Process of Saponin Extraction



Vanillin-Sulphuric Acid Assay

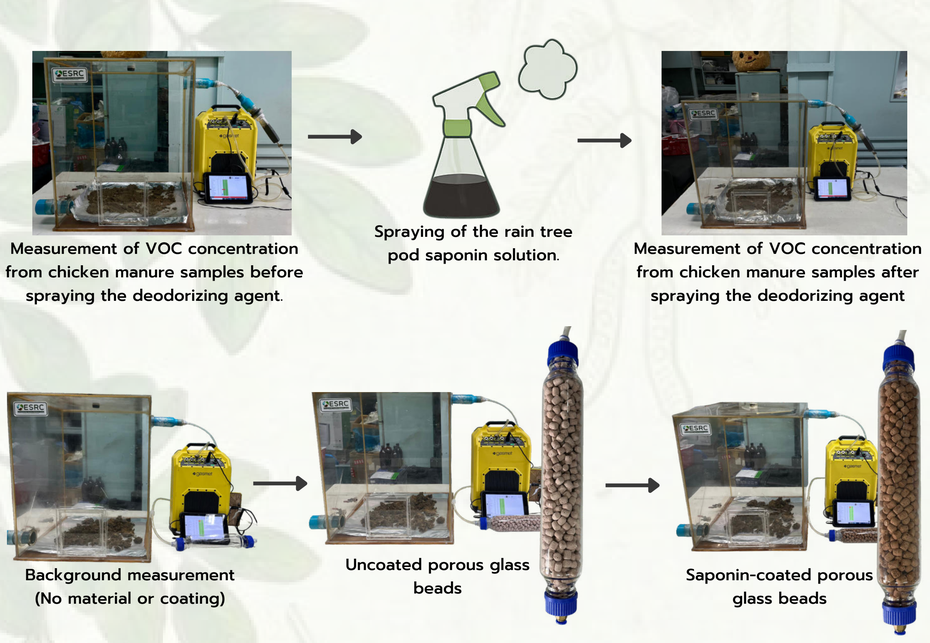


VOC Measurement Method



Collection of chicken manure samples from the poultry house as a representative source of odor and VOCs.

Measurement of VOCs using the Gasmet GT5000 Terra analyzer inside the poultry house and its surrounding environment.



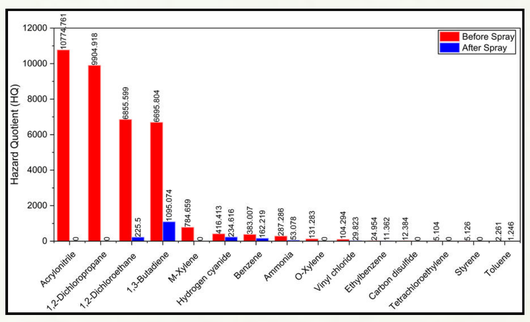
Results & Discussion

VOCs were measured across five locations: the front, middle, and back of the facility, behind exhaust fans, and 10 meters downwind. A total of 50 volatile compounds were analyzed.

Measurement Location	CO_2	NH_3	Methane	Acetic acid	BTEX	TVOC
Front of the house	2.07	0	0.017	0	0.26	1.06
Middle of the house	132.42	3.53	0.157	0.1	0.39	3.13
Back of the house	150.35	4.47	0.207	0.1	0.73	4.32
Behind exhaust fan	252.82	8.72	0.417	11.38	1.31	6.64
10m behind exhaust fan	104.35	3.79	0.343	0.42	0.89	5.11

Chemical	Concentration (ppm)
Hydrogen cyanide (HCN)	0.087 – 0.173
1,1-Dichloroethane	0.047 – 1.143
Chloroform	0.010 – 0.340
Methyl bromide	0.063 – 1.550
Chloropicrine	0.090 – 0.887

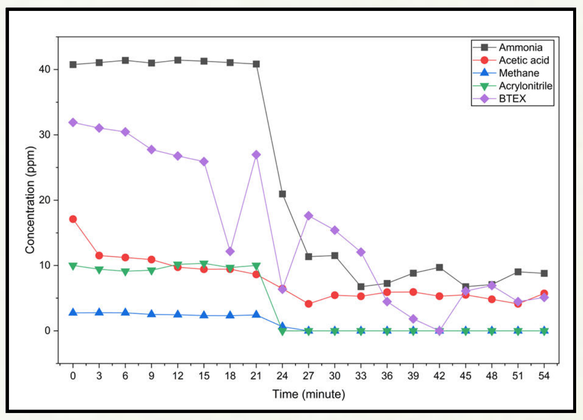
Pre- and Post-Treatment Hazard Quotient (HQ) of Target Compounds



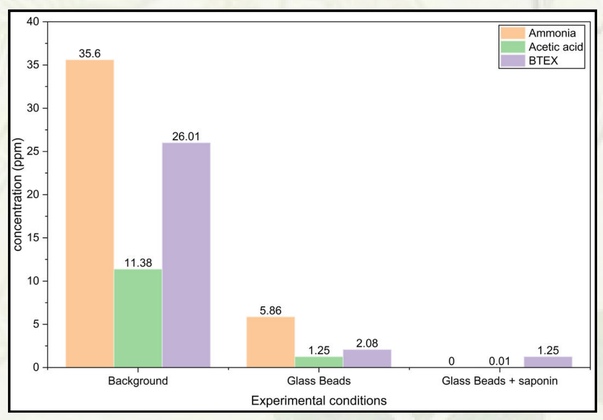
Chemical	Before Spray (ppm)	Before Spray (mg/m³)	RfC (mg/m³)	HQ Before	After Spray (ppm)	After Spray (mg/m³)	HQ After
Acrylonitrile	9.93	21.55	0.002	10,774.76	0	0	0
1,2-Dichloropropane	8.573	39.62	0.004	9,904.92	0	0	0
1,2-Dichloroethane	11.857	47.989	0.007	6,855.60	0.39	1.579	225.5
1,3-Butadiene	6.053	13.392	0.002	6,695.80	0.99	2.19	1,095.07
M-Xylene	18.07	78.466	0.1	784.659	0	0	0
Hydrogen cyanide	1.13	1.249	0.003	416.413	0.637	0.704	234.616
Benzene	3.597	11.49	0.03	383.007	1.523	4.867	162.219
Ammonia	41.243	28.729	0.1	287.286	7.62	5.308	53.078
O-Xylene	3.023	13.128	0.1	131.283	0	0	0
Vinyl chloride	4.08	10.429	0.1	104.294	1.167	2.982	29.823
Ethylbenzene	5.747	24.954	1	24.954	2.617	11.362	11.362
Carbon disulfide	2.783	8.669	0.7	12.384	0	0	0
Tetrachloroethylene	0.03	0.204	0.04	5.104	0	0	0
Styrene	1.203	5.126	1	5.126	0	0	0
Toluene	3	11.306	5	2.261	1.653	6.231	1.246

(The assessment is based on U.S. EPA Reference Concentration (RfC) for inhalation exposure)
The Hazard Index (HI) is the sum of Hazard Quotients (HQ). Post-treatment, the HI dropped from 36,387.83 to 1,812.92, achieving a 95.02% total risk reduction."

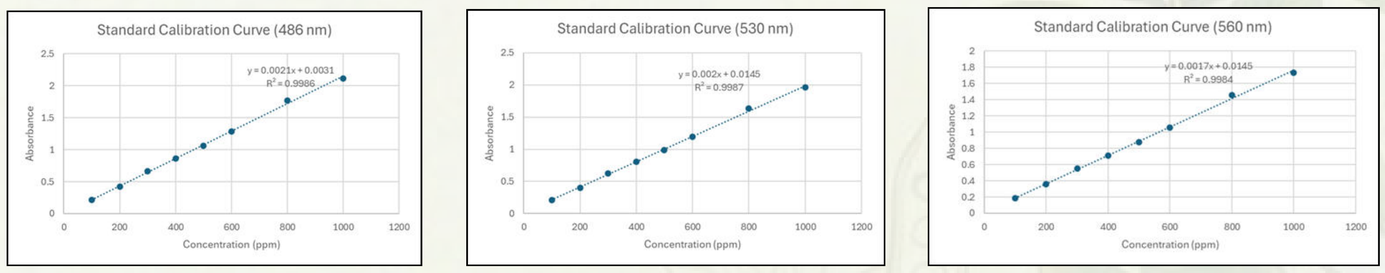
Post-Treatment Concentration of Odorous VOCs



Comparative Analysis of VOCs in the Adsorption Test



Standard Calibration Curve of Saponin Standard



		486nm		530nm		560nm	
		Absorbance	Real Concentration (mg/L)	Absorbance	Real Concentration (mg/L)	Absorbance	Real Concentration (mg/L)
sample A	dilute 100	0.9065	43019.04762	0.8269	40620	0.7094	40876.47059
	dilute 50	1.7785	42271.42857	1.6175	40075	1.3968	40655.88235
sample B	dilute 100	0.3935	18590.47619	0.3586	17205	0.3089	17317.64706
	dilute 50	0.6618	15683.33333	0.5876	14327.5	0.4969	14188.23529

Wavelength	Linear Equation	Correlation Coefficient
486 nm	y = 0.0021x + 0.0031	0.9986
530 nm	y = 0.0020x + 0.0145	0.9987
560 nm	y = 0.0017x + 0.0145	0.9984

Conclusion

This study demonstrates that saponin extract from rain tree pods is a highly effective, sustainable solution for controlling odors and VOCs in livestock facilities. Extracted via PEF and yeast fermentation, the formulation reached a saponin content of 40,301.9 mg/L. Field testing confirmed the reduction of 28 VOCs, with spray application eliminating 100% of Acrylonitrile and reducing Ammonia and BTEX by 81.52% and 80.03%, respectively. Efficiency increased to 100% for Ammonia and 95.15% for BTEX when using saponin-coated glass beads. Ultimately, this innovation reduced the Hazard Index by 95.02%, transforming agricultural waste into a high-performance tool for a circular economy.

Acknowledgement

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