






# Removal of Chromium from Poultry Slurry Using Rice Straw as Locally Available Adsorbent

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**Abstract.** Poultry farms in Bangladesh generate millions of tons of slurry annually, containing high concentrations of heavy metals, making the manure unsuitable for agricultural use. Poultry sludge contains heavy metals like chromium, cadmium, and lead, which can accumulate and pose serious environmental and health risks. Chromium is especially toxic and carcinogenic, potentially causing cancer, organ damage, and contamination. Hence, this research focuses on the removal of chromium from poultry slurry to reduce heavy metal concentrations using a suitable, low-cost, easily available, and environmentally friendly adsorbent for the treatment of biogas slurry. The study includes characterizing the slurry, optimizing adsorption parameters for chromium removal, and minimizing environmental pollution. A total of 17 liquid samples were prepared, including one mother sample, and upon drying, approximately 2 g of solid ground material was obtained from each. The samples were dried in the laboratory and analyzed using a Hot Plate and Atomic Absorption Spectrometer. Rice straw, cut into 1-1.5-inch pieces, was used to adsorb Cr from slurry, with one portion mixed with 0.1N NaOH (treated straw) and dried for one day, while the other portion was left untreated. Chromium removal ranges from 4.62% to 20.57%, with the highest efficiency of 20.57% achieved using 40 g of treated adsorbent for 50 minutes contact period. The optimum contact time was found to be 60 minutes for both treated and untreated rice straw when the adsorbent was 25g. Future studies should investigate the effect of temperature, pH and other heavy metals to optimize and enhance the treatment process.

**Keywords:** Rice Straw, Poultry Slurry, Heavy Metals, Treated Straw, Environmental Pollution, Adsorption.

## 1 Introduction

The poultry industry has seen rapid growth, driven by the rising demand for affordable protein as fish and beef supplies decline. However, this growth generates large amounts of poultry litter, posing environmental challenges such as air, water, and soil contamination due to inadequate management [1]. While poultry litter is valued for its nutrient

content as fertilizer, its excessive production often exceeds farmers' capacity to handle it effectively, creating significant waste management challenges [2].

Biogas production offers a solution by converting organic waste like poultry manure into renewable energy and nutrient-rich slurry. However, this slurry often contains hazardous substances like chromium (Cr), a toxic heavy metal that poses severe health and environmental risks due to its carcinogenic and bio accumulative properties [3, 4]. Traditional methods for heavy metal removal, such as chemical precipitation and reverse osmosis, are costly, energy-intensive, and generate toxic sludge. Adsorption using agricultural residues like rice straw presents a sustainable, low-cost alternative. Rich in cellulose, hemicellulose, and lignin, rice straw is an abundant lignocellulosic material with excellent metal-binding properties [5-7].

This study evaluates rice straw's potential as an adsorbent for chromium removal from poultry manure-based biogas slurry. By optimizing adsorption parameters such as dose and contact time, the research aims to develop an eco-friendly and cost-effective treatment method. The outcomes will contribute to sustainable waste management practices, reduce environmental pollution, and promote the reuse of agricultural residues for environmental remediation.

## **2 Experimental**

### **2.1 Materials**

Around 20 liters sample was collected within one week of its generation. It was collected and carried in pre-washed plastic container.

### **2.2 Sample preparation**

Rice straw, collected from local fields, was cut into 1–1.5-inch pieces, treated with 0.1N NaOH to enhance adsorption, dried for 24 hours, and prepared along with untreated straw for comparison, with experiments conducted using a hot plate and atomic absorption spectrometer (AAS).

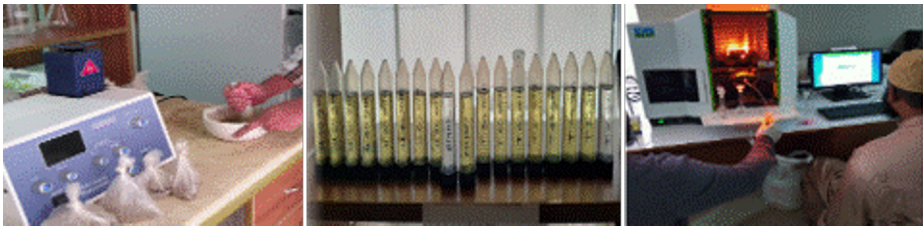
### **2.3 Experimental procedure**

17 samples were made each of 1 liter, including one mother sample. After drying, around 2g of solid ground sample was collected. Four samples were mixed with treated and untreated straw in varying amounts (10, 20, 30, and 40 g for 50 minutes each). Another test used 25g of treated and untreated straw, mixing for 20, 40, 60, and 80 minutes each, as shown in Fig. 1. The dried samples were ground in a porcelain mortar, sieved for homogeneity, and 2g of each sample was placed in beakers. Each sample was treated with 10ml of HNO<sub>3</sub> for organic carbon digestion and left for 18 hours. They were then heat-ed at 120°C for 30 minutes, followed by heating at 240°C with 10ml of HClO<sub>4</sub> to separate Cr from organic bonds.



**Fig. 1.** Preparation of sample

The digested samples were transferred into 50ml volumetric flasks, diluted to 50ml with deionized water, filtered, and collected in 50ml plastic jars, as shown in Fig. 2. Filtered samples were analyzed per the Bangladesh Ministry of Agriculture's fertilizer manual using an atomic absorption spectrometer calibrated with Cr standards (0.1, 0.2, 0.5, 1 mg/L), and final Cr content was calculated by multiplying results by the dilution factor.



**Fig. 2.** Sample analysis using Atomic Absorption Spectrometer (AAS)

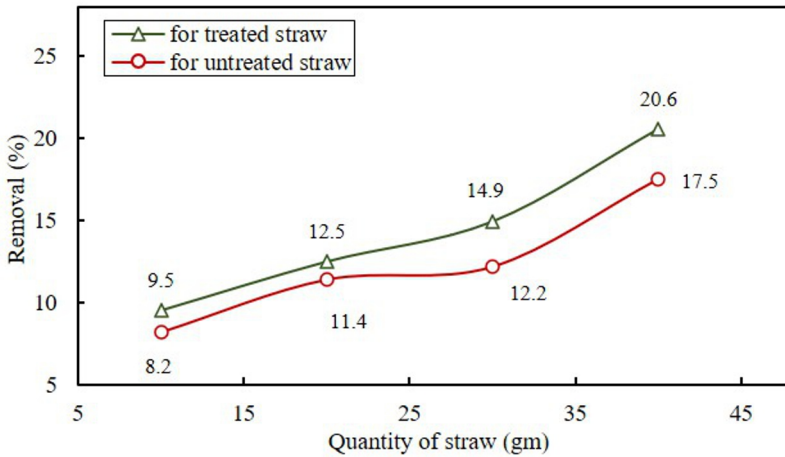
### 3 Result and Discussions

The study using an Atomic Absorption Spectrometer (AAS) showed good absorption capacity of straw, with increased capacity when treated with 0.1N NaOH.

**Table 1.** Results for adding treated and untreated adsorbent for 50 minutes

Sample type	Adsorbent mixed time min	Wt. of adsorbent gm	Wt. of total solid gm	Wt. of Solid gm	Cr mg/L	DF -	Concentration ppm	Removal %
Treated	50	10	34.390	2.039	0.572	24.521	14.026	9.541
		20	34.730	2.038	0.553	24.530	13.565	12.511
		30	28.480	2.036	0.537	24.558	13.188	14.947
		40	34.210	2.026	0.499	24.679	12.315	20.575
Un-treated	50	10	34.12	2.03	0.578	24.615	14.227	8.241
		20	30.65	2.03	0.557	24.656	13.733	11.427
		30	32.78	2.01	0.547	24.886	13.612	12.207
		40	31.90	2.01	0.515	24.834	12.789	17.516

As shown in Table 1 and Fig. 3, Cr removal efficiency increased with contact time for both treated and untreated adsorbents over 50 minutes. The treated adsorbent achieved higher removal rates compared to the untreated one. This indicates that treatment enhanced the adsorbent's efficiency.



**Fig. 3.** Efficiency of treated and untreated adsorbent for 50 minutes contact period

As shown in Table 2 and Fig. 4, Cr removal efficiency increased with contact time for both treated and untreated straw using 25 g of adsorbent. The treated straw showed peak performance at 60 minutes, while the untreated straw showed a steady increase in removal. Overall, the treated adsorbent consistently achieved higher removal, confirming the effectiveness of the treatment process

**Table 2.** Result for adding 25 gm treated and untreated straw for 20, 40, 60, 80 minutes

Sample type	Wt. of adsorbent gm	Adsorbent mixed time min	Wt. of total solid gm	Wt. of Solid gm	Cr mg/L	DF -	Concentration ppm	Removal %
Treated	25	20	32.01	2.00	0.543	24.970	13.559	12.553
		40	33.59	2.01	0.542	24.835	13.460	13.187
		60	29.63	2.03	0.513	24.608	12.624	18.584
		80	29.60	2.02	0.546	24.756	13.517	12.823
Un-treated	25	20	38.59	2.0118	0.595	24.853	14.788	4.627
		40	32.38	2.002	0.557	24.975	13.911	10.281
		60	36.87	2.0055	0.533	24.931	13.288	14.296
		80	35.5	2.0333	0.543	24.591	13.353	13.882

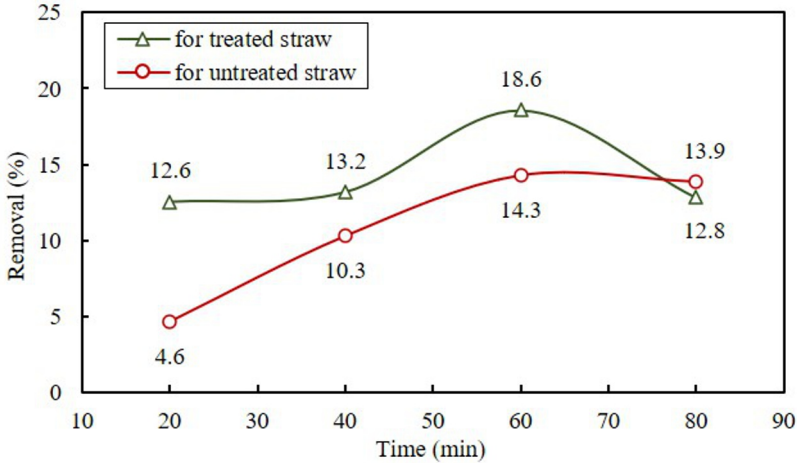


Fig. 4. Efficiency of treated and untreated adsorbent (25 gm) for different contact period

The evaluated data showed that maximum Cr removal efficiency was observed at 50 minutes for 40 g and at 60 minutes for 25 g of both treated and untreated straw.

## 4 Conclusion

Large poultry farms in Bangladesh face challenges with excess manure, which accumulates and causes odor, flies, and environmental concerns when discharged as untreated biogas slurry. This slurry, containing high levels of organic matter, solids, sulfates, sulfides, chromium, and lead, cannot be sold as fertilizer due to regulatory restrictions on heavy metal content. This research explores a low-cost solution using rice straw as a bio-adsorbent to treat biogas slurry. Rice Straw collected from villages, was tested in batch experiments to determine optimal conditions for pollutant removal. Based on the data from the present investigation, the following conclusions are made:

- The results show that rice straw is an effective adsorbent for biogas slurry treatment, achieving Cr removal rates of 4.62–20.57%. The optimum adsorbent dose was 40 g/L, and the optimum contact time was 60 minutes for both treated and untreated rice straw when using 25 g of adsorbent.
- The contact time required to attain equilibrium is dependent of the initial concentrations of the pollutants. For the same concentration, the percentage removal of pollutants increases with increase of contact time till equilibrium is attained.
- Both Langmuir and Freundlich isotherms were followed by the adsorption which indicated the formation of a monolayer of adsorbate on the outer surface of the adsorbent and the heterogeneity of the adsorbent surface. Based on the results of this research, Rice Straw can be considered as available, low cost, environmentally friendly and effective adsorbent for the treatment of biogas slurry.

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**Disclosure of Interests.** The authors have no conflict of interest.

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