



## Evaluation of Various Materials in Water Purification Projects

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### Article Info

**Volume No:** 1

**Issue No:** 2

**Page No:** 53-63

**Received:** 30-10-24

**Accepted:** 28-12-24

**Published:** 28-02-25

**DOI:** 10.51594/gjet.v1i2.111

**DOI URL:** <https://doi.org/10.51594/gjet.v1i2.111>

### Abstract

The challenge of providing clean drinking water is becoming more pressing in the 21st century due to decreasing water resources, increasing populations, and the rising demands of both agriculture and industry. Although several water purification techniques exist, there is a growing focus on adopting more eco-friendly solutions. One such approach involves using solar stills, which offer a reduced carbon footprint. This research conducted an experiment to evaluate the efficiency of four different materials: wiry sponge, black volcanic rocks, coated metallic wiry sponge, and uncoated metallic wiry sponge. The experiment spanned five days, with performance measured hourly. Results indicated that the coated metallic material achieved the highest output, followed by the black volcanic rocks.

**Keywords:** Solar Still, Water Purification, Materials, Volcanic Rocks, Coated Metallic, Experiment.

### INTRODUCTION

At the start of the 21st century, the global population was around 6 billion, and within the first two decades, it exceeded 8 billion. This rapid population growth has increased the demand for agricultural, domestic, and industrial goods. These human activities are exerting significant pressure on freshwater resources, which are becoming progressively limited. In many developing countries, only a small percentage of the population has access to safe drinking water. Consequently, the global need for fresh water continues to rise. The shortage of clean water is also linked to several social challenges, such as food insecurity, the spread of infectious diseases, and regional disputes. This growing crisis underscores the urgent need to develop innovative water purification methods for human consumption. Although the sea

holds an abundant supply of water, its high salinity and chemical content make it unsuitable for direct use.

Desalination is gaining popularity worldwide as a means of producing clean water. Common techniques used for this process include electrodialysis, reverse osmosis, and different distillation methods. It is crucial for these purification methods to adopt environmentally sustainable practices. Several leading countries are now integrating renewable energy sources into their desalination facilities. This approach is especially useful in arid regions and remote islands, where high transportation costs make solar energy a practical solution for water purification. Desalination plants powered by renewable energy provide benefits such as lower carbon emissions, improved sustainability, and reduced long-term operational expenses. However, a significant disadvantage is the higher initial investment required for installation.

In this regard, Prasad and Tiwari (1996) made a notable contribution by incorporating a compound parabolic concentrator into the solar still basin to produce extra thermal energy for water purification. This approach is known as an active solar system. Their research indicated that increasing the glass cover's inclination improves thermal energy generation. This finding implies that optimizing the angle of the glass cover can lead to greater efficiency in the system.

In 2011, Badra investigated the thermal efficiency of a single solar still combined with a solar collector, examining the impact of different insulation thicknesses (3 cm and 6 cm). The study also considered factors such as the temperature difference between the water and the cover, wind speed, transmissivity, absorptivity, and the overall heat loss coefficient. The results showed that circulating heated water from the solar collector to raise the basin water temperature could improve the system's overall efficiency.

In 2011, Singh conducted an experimental study to evaluate the performance of a single-slope solar still under varying weather conditions, including sunny and cloudy days. The findings indicated that integrating a solar water heater with a nocturnal system in the solar still basin could increase production by up to 120%. Similarly, Mamlook and Badran (2006) utilized fuzzy logic in analyzing solar distillation systems. Their research demonstrated that factors such as water depth, solar concentration, coupled collectors, sprinklers, solar intensity, ambient temperature, and wind speed significantly affect the solar still's output.

Boukar and Hannim (2001) conducted a study comparing a basic solar still with a similar system that included a flat plate collector. The experiment was performed under open conditions with different water depths. During the summer, the basic system produced a minimum of 4.01 l/m<sup>2</sup>/d, while the system with the flat plate collector showed significantly higher efficiency, reaching a minimum output of 8.02 l/m<sup>2</sup>/d.

Abdallah, Abu-Khader, and Badran (2009) conducted a study examining the impact of heat-absorbing materials on the performance of four identical solar stills. The first three stills were filled with wiry sponge, black volcanic rocks, coated metallic material, and uncoated metallic wiry sponge, while the fourth still, without any absorbing material, served as a control. The results indicated that the uncoated wiry sponge achieved the highest water collection compared to the other materials.

Badra (2011) developed a system that integrated reflecting mirrors on the slope of a solar still combined with a flat plate collector. The comparison revealed that this design improved water production. The study also concluded that increasing the basin water depth decreased productivity, while the solar still's output was directly related to the intensity of solar radiation.

Shanmugan, Rajamohan, and Mutharasu (2008) conducted a study where a booster mirror was placed above the glass cover of a 1 m<sup>2</sup> still basin. Their findings indicated that using the booster mirror increased overall water production. The current study seeks to examine whether integrating a concave wick surface for evaporation and a pyramid-shaped still with

four condensation sides can enhance productivity. The inclusion of a jute wick improved solar absorption while also increasing the evaporation surface area. Additionally, the concave wick, through its capillary action, further expanded the evaporation surface. The cost of producing one liter of distilled water using this solar still was estimated at \$0.071, with an average output of 3.99 m<sup>2</sup>/d.

### **EXPERIMENT-MATERIAL AND METHODS**

The experiment involved combining rows of parallel transparent evacuated glass tubes (EGTs) with a single-slope passive solar distillation unit. Each unit featured an absorber tube with a selective coating designed to preheat the water before entering the solar still. The solar still was connected to the evacuated glass tubes, which circulated water from the basin. Solar radiation passed through the outer glass while the absorber tube heated the water as it flowed through. The modular design of the EGTs allowed for adding or removing tubes based on the required water temperature. The solar still included a fiber-reinforced plastic (FRP) painted basin with an area of 1 m<sup>2</sup>, which supplied brackish water preheated by the EGTs using solar energy. A toughened glass sheet covered the evaporation basin, allowing solar rays to reach it. The glass cover, tilted at approximately 40 degrees, retained heat and promoted continuous evaporation. A trough at the bottom collected the distilled water, while an inlet pipe supplied water to the still. K-type thermocouples were inserted through drilled holes to monitor temperature. The system was insulated with polyurethane foam on the sides and base to minimize heat loss, and silicon rubber was used as a sealant to prevent leakage. A dammar roll was affixed to the top of the glass cover. To maintain a constant brackish water level of 10 cm during the experiment, a constant head tank was used. The technical specifications of the setup included a basin area of 1.5 m<sup>2</sup>, a glass cover inclined at 35 degrees, a glass area of 1.035 m<sup>2</sup>, and a glass thickness of 7 mm. The system utilized 20 evacuated glass tubes with an outer diameter of 75 mm, an inner diameter of 55 mm, and a length of 2250 mm, inclined at 27 degrees. The experimental system was placed outdoors under clear skies and moderate temperatures.

### **RESULTS**

The experiment measured the ambient temperature and average water collection output (in ml) over the course of a week. At hour 1, the weekly average temperature was recorded at 32.34°C. During this time, the average water collection output was 17 ml for wiry sponge, 15 ml for black volcanic rocks, 23 ml for coated metallic, and 18 ml for uncoated metallic wiry.

At hour 2, the ambient temperature increased to 33.56°C. The corresponding average water collection output was 29 ml for wiry sponge, 30 ml for black volcanic rocks, 35 ml for coated metallic, and 30 ml for uncoated metallic wiry.

By hour 3, the weekly average temperature rose to 36.5°C. At this point, the water collection output increased to 50 ml for wiry sponge, 79 ml for black volcanic rocks, 101 ml for coated metallic, and 79 ml for uncoated metallic wiry.

The results indicate that the coated metallic material consistently produced the highest water output across all measured hours, suggesting its superior efficiency in enhancing water collection.

		Average Output of Water Collection (ml)											
		Ambient Temperature (C) Day Wise					Average Output of Water Collection (ml)						
Time	Day 1	Day 2	Day 3	Day 4	Day 5	Ave	Wiry Sponge	Black Volcanic Rocks	Coated Metallic	Uncoated Metallic	Wiry	Wiry	
Hour 1	35	30.2	27	40.5	29	32.34	17	15	23	18			
Hour 2	36.5	30.5	29.8	41.5	29.5	33.56	29	30	35	30			
Hour 3	37.2	39.7	33.6	38.5	33.5	36.5	50	79	101	79			
Hour 4	39.4	39.8	37.5	40.2	39.5	39.28	265	245	305	201			
Hour 5	40.2	41.3	40.2	43.2	40.2	41.02	375	234	553	352			
Hour 6	41.5	41.3	41.5	42.6	43.5	42.08	502	575	601	379			
Hour 7	43.5	44.5	46.2	46.5	44.6	45.06	762	995	786	453			
Hour 8	44.6	47.9	43.2	45.2	45.7	45.32	792	965	955	567			
Hour 9	40.2	40.7	40.1	41.2	47.6	41.96	566	960	995	765			
Hour 10	37.2	39.5	38.5	40.6	40.2	39.2	768	953	1105	813			
Hour 11	38.2	36.3	36.7	39.5	39.5	38.04	678	855	1085	765			
Hour 12	30.1	32.1	30.2	33.5	37.5	32.68	233	533	768	554			
<b>Total</b>	<b>463.6</b>	<b>463.8</b>	<b>444.5</b>	<b>493</b>	<b>470.3</b>		<b>5037</b>	<b>6439</b>	<b>7312</b>	<b>4976</b>			

At hour 4, the weekly average temperature reached 39.28°C. The average water collection output was 265 ml for wiry sponge, 245 ml for black volcanic rocks, 305 ml for coated metallic, and 201 ml for uncoated metallic wiry.

At hour 5, the temperature increased to 41.02°C, resulting in an average output of 375 ml for wiry sponge, 234 ml for black volcanic rocks, 553 ml for coated metallic, and 352 ml for uncoated metallic wiry.

At hour 6, the temperature further rose to 42.08°C, and the corresponding water collection was 502 ml for wiry sponge, 575 ml for black volcanic rocks, 601 ml for coated metallic, and 379 ml for uncoated metallic wiry.

At hour 7, the weekly average temperature reached 45.06°C, with water outputs of 762 ml for wiry sponge, 995 ml for black volcanic rocks, 786 ml for coated metallic, and 453 ml for uncoated metallic wiry.

At hour 8, with a temperature of 45.32°C, the water collection was 792 ml for wiry sponge, 965 ml for black volcanic rocks, 955 ml for coated metallic, and 567 ml for uncoated metallic wiry.

At hour 9, the temperature began to decline to 41.96°C, with water outputs recorded at 566 ml for wiry sponge, 960 ml for black volcanic rocks, 995 ml for coated metallic, and 765 ml for uncoated metallic wiry.

At hour 10, the temperature was 39.2°C, and the outputs increased to 768 ml for wiry sponge, 953 ml for black volcanic rocks, 1105 ml for coated metallic, and 813 ml for uncoated metallic wiry.

At hour 11, with a temperature of 38.04°C, the water collection was 678 ml for wiry sponge, 855 ml for black volcanic rocks, 1085 ml for coated metallic, and 765 ml for uncoated metallic wiry.

At hour 12, as the temperature dropped to 32.68°C, the average water output decreased to 233 ml for wiry sponge, 533 ml for black volcanic rocks, 768 ml for coated metallic, and 554 ml for uncoated metallic wiry.

### CONCLUSION

This study focused on water desalination using the solar still technique, recognized for its environmentally friendly nature due to its low carbon footprint and cost-effectiveness. The research examined the performance of four different materials—wiry sponge, black volcanic rocks, coated metallic, and uncoated metallic wiry sponge—through an experimental approach. Conducted over one week, the experiment involved monitoring water collection during a 12-hour period each day. The findings indicated that coated metallic material demonstrated the highest water collection output throughout the experiment. Black volcanic rocks ranked second in performance, while wiry sponge and uncoated metallic wiry sponge yielded lower water collection rates.

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Appendix: Charts

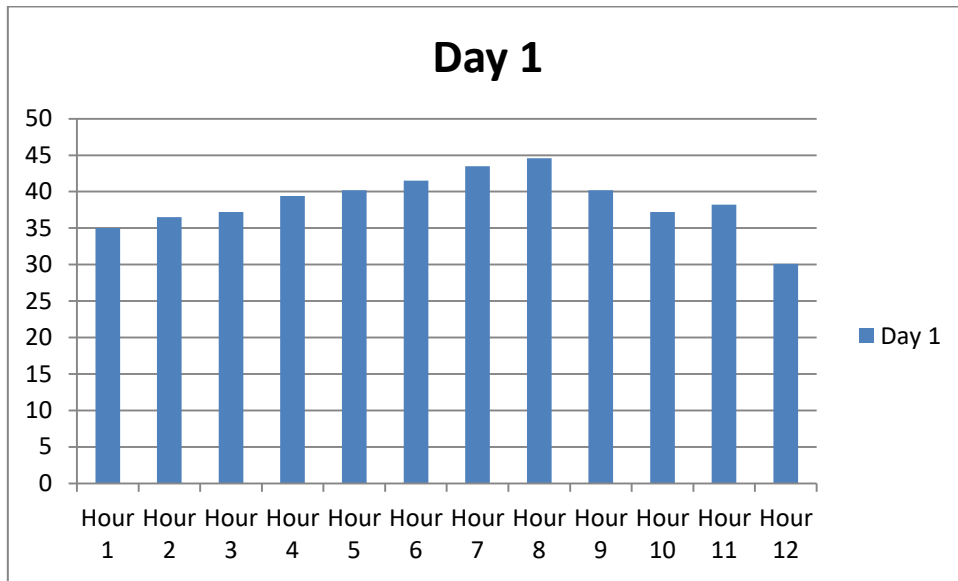


Figure 1: Day 1 Result

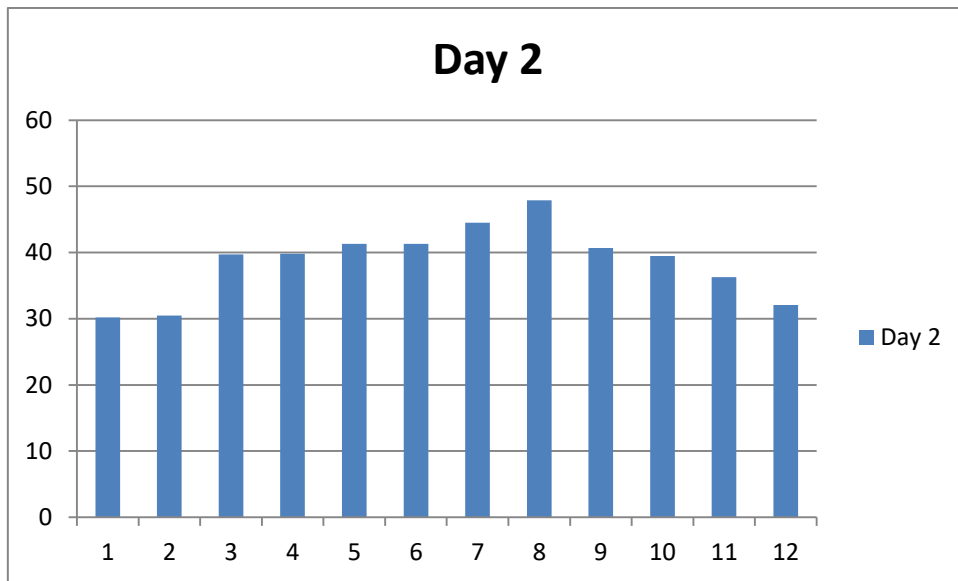


Figure 2: Day 2 Results

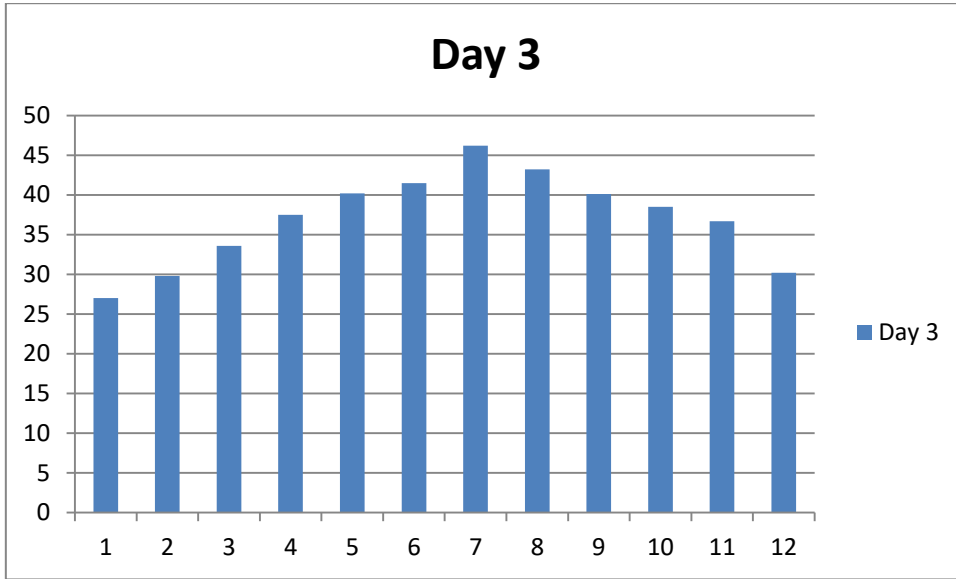


Figure 3: Day 3 Results

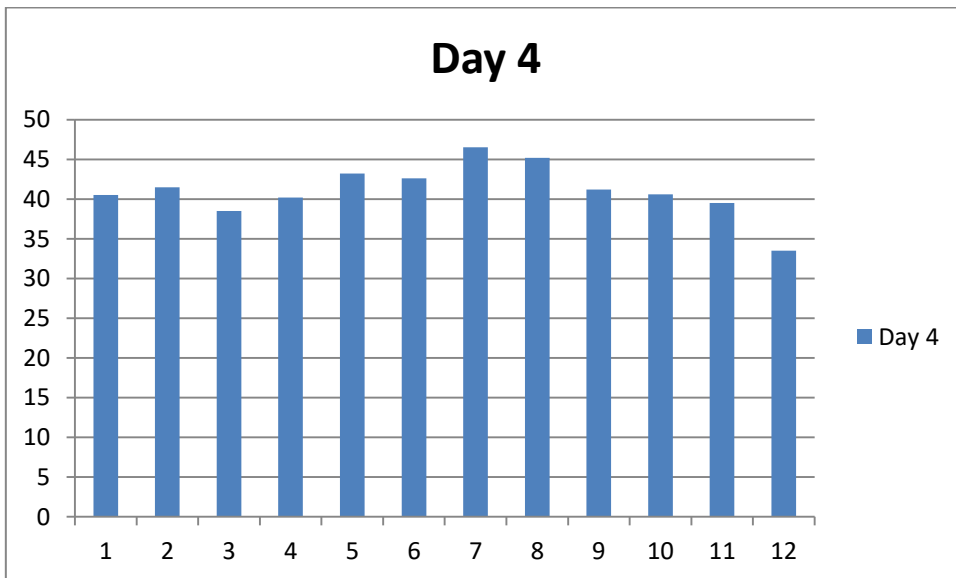


Figure 4: Day 4 Results

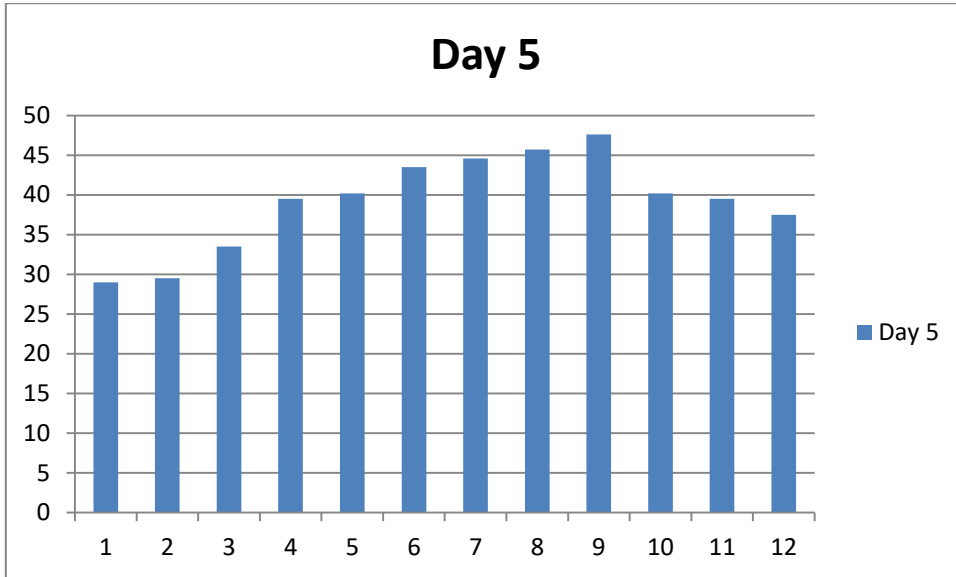


Figure 5: Day 5 Results

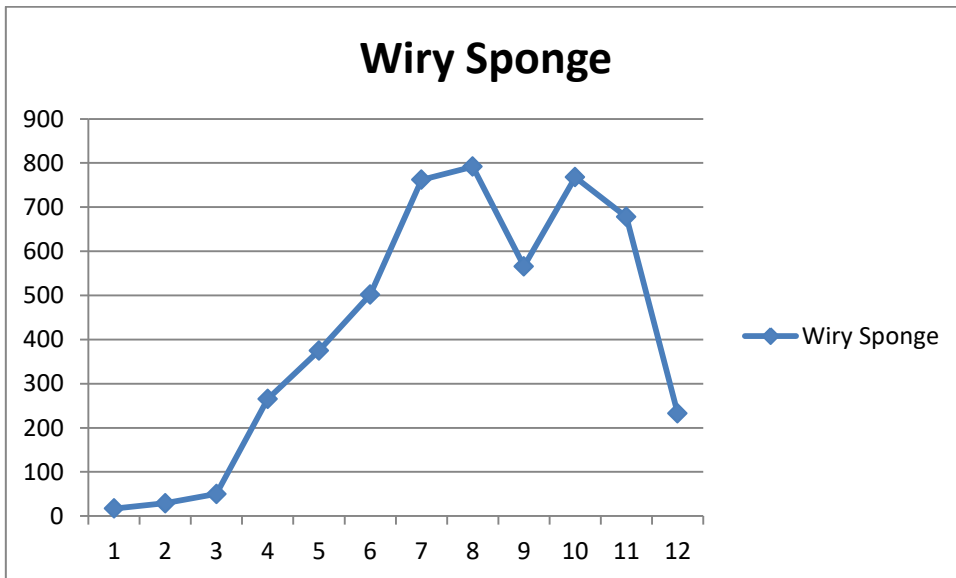


Figure 6: Wiry Sponge

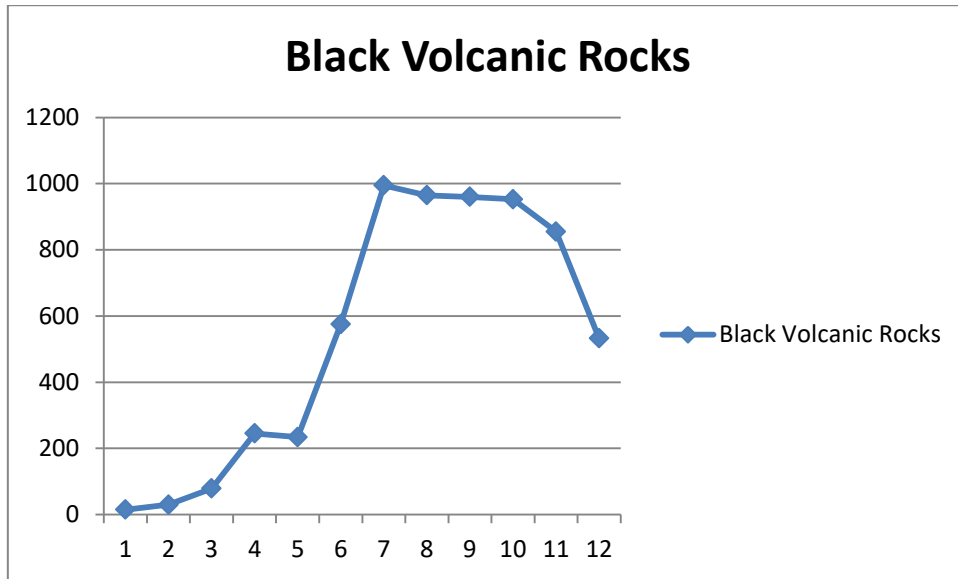


Figure 7: Black Volcanic Rocks Results

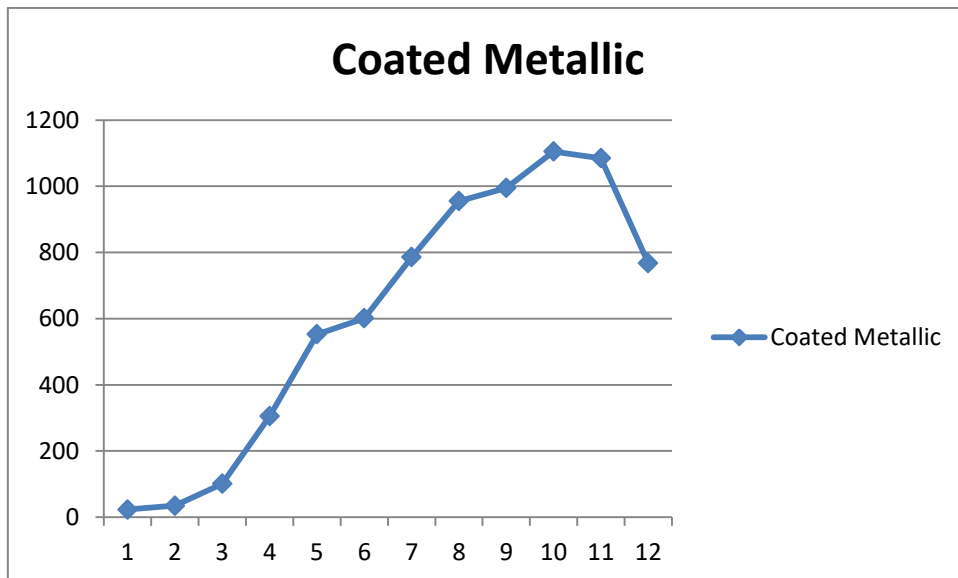


Figure 8: Coated Metallic Results

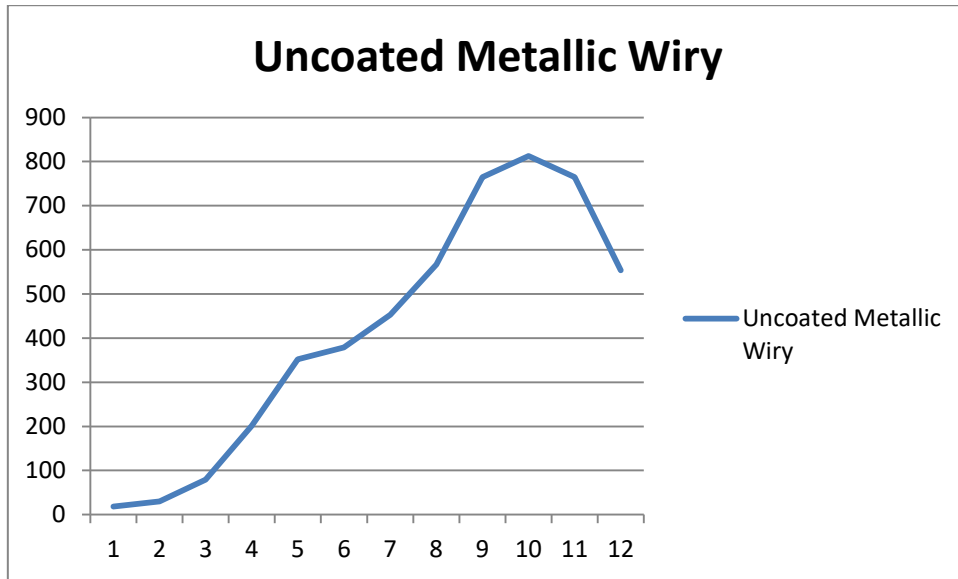


Figure 9: Uncoated Metallic Wiry

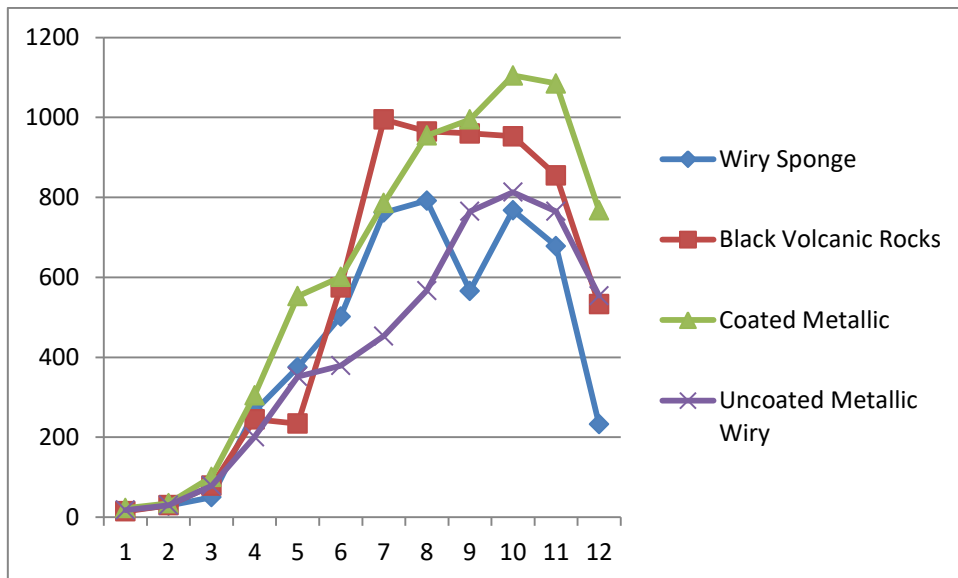


Figure 10: Comparative Results