# Potential Of Carbonized Rice Husk As A Filter Media Rain Garden To Decrease The Turbidity Of Water And Coli Bacteria In The Stormwater Runoff. A Review Of Current Research

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# Potential of carbonized rice husk as a filter media rain garden to decrease the turbidity of water and Coli bacteria in the Stormwater Runoff. a review of current research

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**Abstract**. The rapid development of physical infrastructure and infrastructure activities in several metropolitans in Indonesia, followed by industrial, transportation, construction, trade, and office canters, have had an impact on the environment. Such facilities cause a reduction in a green open space. The existence of high rainfall causes uncontrolled stormwater run-off. As a result of the massive floods that frequently happen. The problem that often found that stormwater run-off tends to result in high turbidity and pollution of Coli bacteria, so processing of the treatment is necessary. One of the methods of maintaining the quality of water can use rain gardens that can be made in a run-off water source, by using carbonized rice husk filters. This research method was carried out with the technique of literature review, such as national and international journals, books, websites, and other documents related to the topic of study. Based on the results of the study, carbonized rice husks were able to decrease turbidity and Coli bacteria with decent removal efficiency approaching 90%. The carbonized rice husk becomes an alternative for the media filter rain garden to decrease the value of turbidity and the number of Coli bacteria, as it has large pores and has a content of high Silica (Si).

## 1. Introduction

The rapid development of physical infrastructure and infrastructure activities in several metropolitan areas in Indonesia, followed by industrial, transportation, construction, trade, and office centers, has had an impact on the environment. The installation also resulted in a decreased number of GOS (green open space) cities. The lack of GOS has led to a decline in the quality of the environment marked by increased air temperature, decreased soil water, flooding or inundation, dirt surface degradation, the intrusion of seawater, coastal abrasion, and so on (1)(2).

The unpleasant urban atmosphere makes it uncomfortable for urban communities living in the cities, so it decreases productivity and the welfare of human populations living in the cities (3)(4). The conditions of the environment of the urban areas become increasingly severe when the rain fell. The average rainfall passed down by the tropical region is very dense and, in high intensity, were more than 2,000 mm.year$^{-1}$ (5). Only two hours of rain can cause a prevent puddle, even flooding. The reason is that people are only able to rely on water canals as stormwater run-off. The problem is, most of the drains didn't function properly because they're clogged with waste or because sediments never dredged. Recently, communities have been introduced with stormwater absorption techniques to ease the water canal. Such absorption technique included the production of bio pores, infiltration wells, conblock, or grass block. These techniques can be applied to individual courtyards. But the problem is, these techniques still have flaws, Bio pores, infiltration wells, conblock, and grass block can only help absorb stormwater, but not for dangerous substances brought by rain. Hazardous materials like this, if incorporated into the soil, can interfere with the fertility of the ground. If carried away by the channels of water heading into the canal, the river and then the ocean can also harm the ecosystem.

Water is an essential environmental component of life. Communities also use water functions besides as constituent to live creatures for household needs such as bathing, washing, cooking food, and other household needs. Water is an essential resource for human life, both for consumption and other purposes. However, there is very little water supply due to many polluted water resources (6). The daily needs of Indonesian people generally use water resources in the environment, such as rivers, wells, and swamps. They do this due to limited associated water support facilities. The limited supply of qualified freshwater needs to be appropriate technologies adapted following the environment for manufacturing the water system (7).

Often the problems are found with stormwater run-off received that they carry pollutants or even chemicals that are dangerous for people such as copper, cadmium, chrome, tin, and zinc, which are dissolved in stormwater. Besides, the number of Coli bacteria tends to be high (8). In other studies, the concentration of pollutants on rainfall in urban areas holds up to 35-1500 mg. $L^{-1}$ total suspended (TSS), 1-6 mg. $L^{-1}$ total nitrogen, 0.6-3 mg. $L^{-1}$ the total phosphorus, and 50-1000 $\mu$g. $L^{-1}$ heavy metal (such as Cu, Pb, and Zn) (9)(10). The presence of herbicides, such as glyphosate (N-phosphonomethyl glycine) in stormwater run-off urban, also many have already reported (11)(12)(13)(14). The rain garden is one of the methods to manage the run-off of the rain that can be applied near the drainage of stormwater. The technology of rain gardens is also referred to as a biofilter or which has multifunction in maintaining the environment (15). This paper will be discussed how to manage the run-off of the stormwater using the rain garden method and the effectiveness of the carbonized rice husk as the alternative filter media for a rain garden.

## 2. Materials and methods

### *2.1. Rain Garden Concept*

The rain garden is a natural expanse like a garden comprising a combination of soil and leaves and plants. A rain garden is also called a bioretention area, in which it's designed to hold stormwater filters temporarily, and it helps the infiltration and evaporation process. A rain garden is designed to allocate a quick infiltration using an accelerated penetration. Rain gardened on the scale of households, no natural engineering, and used the original land (4).

Rain is designed to stream fast run-off by infiltrating the accelerated infiltration. Rain gardens are made on the household scale, with no natural engineering and use of native land. Using original native species plants in the region that contain aesthetics, and assist in the process with an inclusion zone as macropore. Rain garden not only beautifies a space but has great benefits for the environment. To create a rain garden involves several things, hydrological cycle, layout, conservation of resources, creation of artificial habitat, psychologist, soil chemical, horticulture, surface design, and ecology.

The process that occurs in the rain garden system should be understood so that this technology can be used optimally. The primary method in rain garden for local rain began with the intersection, namely the process of trapped the stormwater by the plant leaf and the closing layer, thus slowing or decreasing the flow of the surface. The second process is infiltration. This is the primary process in the rain garden, both those with underdrains and those with no channels. The sediment will occur as a result of the slow stream in bioretention so that particles in the water will be left at the surface of the rain garden. Absorption is the process of water containment in the space between the soil particles that will then be absorbed by the roots of the plants. The next process is evapotranspiration occurring in a rain garden and will turn some of the run-offs into water vapors (16). This development causes changes to the landscape from natural to more rigid and hard. It causes stormwater that drops in this area to be unabsorbed and to become run-off water that will disturb the surrounding environment—one way to be able to manage the stormwater by developing a garden in the location. The Rain garden is made commonly and does not require special preparation or treatment (4).

Besides, according to the previous studies, the effects of the better plant election are expected to improve the effectiveness of the rain garden. The election of the plants is based on the soil conditions, sunlight exposures, and other conditions around the rain garden. Some plants can grow wholly with full sunlight, some sun lighting, or even just being able to live in the shade. Other than that, we should also consider plant capacity in tolerating droughts. Selected plants should be able to survive in dry circumstances or drought season. In that season, the plant needs a livelihood to be able to live, growth and crop size. Consider the height of the plants, the spread, and the root system. The layout of the plant should not disrupt any other facility, such as a buried pipe, cable, or disposal tank. If placed near the road or car park, consider the rooting problem, do not case the problem resulting from the root that appears to surface (17)(18).

### *2.2. Hydrological Cycles and Run-Off*

The hydrological cycle is the circulation of water from the ocean to the atmosphere and then back to the Earth and forth. The water from the sea level evaporates into the air, moves and upwards to the atmosphere. Then condenses and turned into a cloud-shaped water point and subsequently plunged into the Earth and the seas as rain. The rain that fell to Earth was partly held up by the plants, and some others soaked into the ground. If the land had become saturated, then the water would flow on the soil surface, which filled with basins, lakes, rivers, and back to the sea (19).

The flow of water can enter its soil via soil pores. This process is called infiltration. In the land media, the direction of water flows laterally as an interflow, which leads to the spring, lake, and river, or vertically, which is known as percolation to the ground. The gestures on the soil media through the pores are affected by the gravitational force and capillaries. The gravitational force causes the flow always to go lower places, while the capillary style causes the water to move in all directions. If the intensity of the rain falling on a DAS exceeds the infiltration capacity, after the infiltration rate was filled, the water would fill up gaps on the ground's surface. After the basins are full, further water will flow (abundant) on the surface of the land (20).

Concentration time is the time required for water to flow from the farthest point in the catchment are to the end of a view (control point). By the time of this concentration, all of the catchment areas contributed to the stream at the control point. Concentration time depends on catch area characteristics, land use, and water track distance from the farthest point to the end of being reviewed. Stormwater, which falls across the ocean areas, will be concentrated (flowing into) a control point. Stormwater, which hit the entire captured area, was running as a run-off of the surface, which then went into smaller channels and then joined the larger chains and then concentrated at the control point (20).

When the rain falls in the area that nature is of land covered in trees, reeds, and grass on the territory of forest or plantation then the storm is at first relative to just wet the foliage (canopy storage) and after that twigs of trees that began soaked then the branches and the tree trunk (streamflow). The water will flow continues to moisten the dry leaves that have fallen, then moisten the grass. After all, the relatively new wet the surface of the soil begins to moisten. Once the land starts to wet, then seep into the ground until it becomes saturated groundwater flow or surface water run-off starts to occur (4). Surface run-off is stormwater that drains through thin layers above the surface of the land, going into trenches and sewers that eventually join into river water and eventually become a stream. In the mountainous area (the upstream part of the watershed), The surface run-off sprawl could sink into the river quickly, which could cause the river to increase. If the stream is larger than the river's capacity to flow into the flows, there will be a spillover on the river's banks and cause flooding (15).

### *2.3. The Requirement of the Water Quality*

The requirement of the water quality is right according to the Regulation of the Minister of Health of the Republic of Indonesia Number 32 the Year 2017 About the Standard of the Health of the Environment and Health Requirements of Water For purposes of Hygiene and Sanitation, Swimming Pool, Solus Per Aqua, and the Public Baths are aware that for the media the water used for Hygiene and Sanitation includes the parameters of the physical, biological, and chemical which can be in the form a mandatory parameter and additional parameters (Table 1). A mandatory Parameter is a parameter that should be checked periodically following the provisions of the legislation. In contrast, other parameters are only required to be checked if the conditions of geohydrology indicate the presence of potential contamination associated with the additional parameters. Water for Hygiene, Sanitation, are used for the maintenance of personal hygiene such as a bath and brush your teeth, as well as for purposes of washing food, eating utensils, and clothing. Table 2 contains a list of mandatory parameters for biological parameters, which should be examined for sanitary hygiene purposes, which include total coliform and Coli bacteria (colony-forming units in 100 ml of water samples).

**Table 1.** The physical parameters in the quality standard of the health environment.

| No. | Required Parameter | Unit | Quality Standards (Maximum Level) |
|---|---|---|---|
| 1. | Turbidity | NTU | 25 |
| 2. | Colour | TCU | 50 |
| 3. | Total dissolved solids | $mg.\ L^{-1}$ | 1000 |
| 4. | Temperature | $^{o}C$ | Air temperature ± 3 |
| 5. | Taste | - | No Taste |
| 6. | Odour | - | No odour |

**Table 2.** The biology parameters in the quality standard of the health environment.

| No. | Required Parameter | Unit | Quality standards (maximum level) |
|---|---|---|---|
| 1. | Total coliform | $CFU.100ml^{-1}$ | 50 |
| 2. | Coli bacteria | $CFU.100ml^{-1}$ | 0 |

### *2.4. Data Analysis*

The method of this research was conducted with the technique of Literature reviews such as national and international journals, books, websites, and other documents related to the topic of study. This search focused on the keywords provided by Coli bacteria, turbidity, rain garden, carbonized rice husk, stormwater run-off. The problem of research is studied by describing the study subject circumstances based on facts and research of various sectors. Analyses the data have done descriptively by displaying the data in table and image shapes.

## 3. Results and Discussion

### *3.1. The Effectiveness of Rain Garden*

Rain garden developed by Dietz and Clausen, according to specifications in the recent manual design of Prince George County, MD (21). At the same time, the sighting of the model in **Figure 1**. In that model, the land located in a rain garden tub coated with a seam coming from a wooden piece, which is 5 cm. There are two waste pipes, which serve as the water sample site. The tube is located at the top and on the base of the model. The diameter pipe is 10.2 cm. The pipe is located at the bottom of the rain garden, covered by rocks with a height of 2.5 cm. Media rain garden has the characteristics of sand amounting to 83.0-84.0 %, Silt 7-10%, and clay 6.0-8.0% (21).

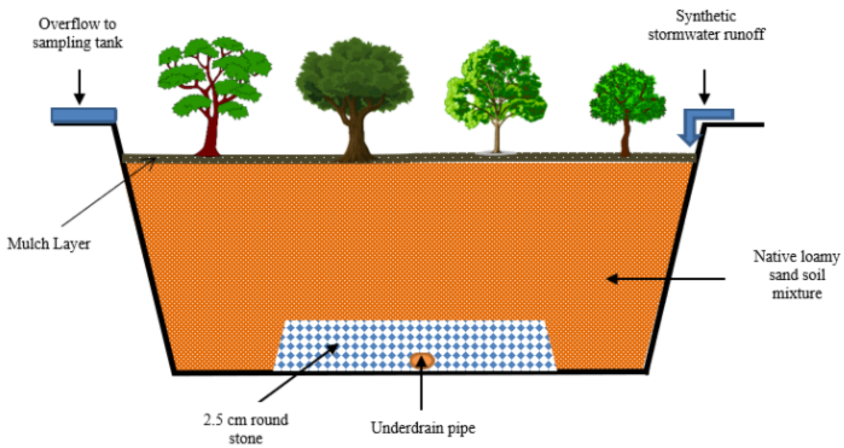


**Figure 1.** Layout rain garden.

Based on the results of the study Dietz and Clausen, by making two pieces of a rain garden as a test, showed that only about 0.8% of the flow of the incoming water leaving the rain garden as water run-off. Most of the 99.2% of entry as the flow under the surface. Based on the results of the same study showed that the value of ammonia - N ($NH_3$ - N) and total N is very significant absorbed by the rain garden. Dietz and Clausen added that there was no significant difference in the concentration of $NO_3$ - N, TKN (Total Kjeldahl Nitrogen), or ON (organic nitrogen) found in between the rainfall, the inlet or the intensity of the underdrain. However, the concentration of $NH_3$ – N from the underdrains significantly ($p = 0.001$) lower than $NH_3$ – N concentration in precipitation and the inlet. This means that the concentration of $NH_3$ - N approach the limit of detection for rainfall and the inlet, and at the threshold of detection for underdrains (21).

The concentration of TN (total nitrogen) of the underdrain of rain garden 1 is significantly ($p = 0.05$) lower than the rainfall and the concentration of TN inlet; TP (total phosphorus) concentration in the inlet was significantly ($p= 0.001$) greater than the precipitation. Interestingly, the concentration of TP in the effluent from the second underdrains has a value substantially higher than both the rainfall and the concentration of the inlet. However, TP concentration higher from the underdrains than the inlet of the after was analyzed using ANOVA. The average concentration geometric mean TP at the inlet (regression not significant) is 0.019 mg. $L^{-1}$, while the average of the two underdrains, shows the trend of exponential decay (R2 = 0.6). The amount of concentration of phosphorus at the inlet and underdrains towards the end of the study period is similar. Based on these results, the researchers suspect that the disorders of the land at the beginning of the study period is the cause of the increase in the concentration of phosphorus at the outlet. Rain garden application can be said as one form of implementation of biofilter that can remove hazardous materials from stormwater. Based on research, the performance of a rain garden can significantly decrease the number of Coli bacteria (0.6 logs) and protozoa (2 logs) (21). A Rain garden not only serves as a water-absorbent but can also purify it. Even in some studies, the existence of a rain garden can suppress the pollution in the river up to 30 percent (22). Many studies have also reported benefits from the presence of a rain garden (Table 3).

**Table 3.** Summary of rain garden effectiveness in removal pollutants.

| Location | Removal Pollutant | | Source |
|---|---|---|---|
| Study of two rain garden constructions, Haddam. CT | – $NH_3$-N<br>– $NO_3$<br>– TKN<br>– TN<br>– ON | : 84.6%<br>: 35.4%<br>: 31.2%<br>: 32.0%<br>: 21.3% | (21) |
| Studies in the box to the laboratory for six hours, the average flow and the time of 4.1 cm.h$^{-1}$ | – Phosphorus ($\mu$g. L$^{-1}$)<br>– Nitrate nitrogen ($\mu$g. L$^{-1}$)<br>– TKN ($\mu$g. L$^{-1}$) | : 99 ± 0<br>: 97 ± 3<br>: 97 ± 2 | (23) |
| Studies in boxes laboratory: double flow with a speed of 8.1 cm.h$^{-1}$ | – Phosphorus ($\mu$g. L$^{-1}$)<br>– Nitrate nitrogen ($\mu$g. L$^{-1}$)<br>– TKN ($\mu$g. L$^{-1}$) | : 73 ± 13<br>: 70 ± 14<br>: 73 ± 14 | (23) |
| Largo, MD | – Copper ($\mu$g. L$^{-1}$)<br>– Lead ($\mu$g. L$^{-1}$)<br>– Zink ($\mu$g. L$^{-1}$)<br>– Calcium ($\mu$g. L$^{-1}$)<br>– Phosphorus ($\mu$g. L$^{-1}$)<br>– Nitrate nitrogen ($\mu$g. L$^{-1}$)<br>– TKN ( $\mu$g.L$^{-1}$) | : 43% ± 11<br>: 70% ± 23<br>: 64% ± 42<br>: 27% ± 14<br>: 87% ± 2<br>: 15% ± 12<br>: 67% ± 9 | (22) |

### *3.2. Factors that affect filtration with carbonized*

According to Ronny and Saleh, several factors affect the filtration process in the carbonized filter during the process of adsorption. The first is the discharge that is too large will lead to the not proper functioning of the filters efficiently so that the filtration process cannot occur with the perfect, due to the water flow too fast through the cavity between the granules of the sand media. This results in a decreased time of contact between the surface of the granular filter media with the water to be filtered. The flow velocity is too high while passing through the cavity between the granules to cause the particles are also finely filtered will pass. The thick-thin medium will determine the duration of the jetting and filter power. The Media, which is too thick, has very high filtered power, but it takes time jetting long. The larger the surface area of the adsorbent, the more adsorbate that can be absorbed so that the process of adsorption can be more effective, the smaller the particle diameter than the surface area of the adsorbent (24).

The contact time is a very determining factor in the adsorption process, and longer contact time allows for diffusion and paste of adsorbate molecules to work better. The concentration of organic matter and later solutes will be well adsorbed if the contact time is longer with slow water flow. Besides, the media that is used must be dry, so this can improve the process of oxidation, as water will permeate into the filter media for longer than water which is permeating into the wet media filter, this will extend the time of the contact so that the process of oxidation will run more efficiently.

### *3.3. The effectiveness of carbonized rice husks to removal turbidity and Coli bacteria*

Turbidity in water rain comes from the mud that dissolves with stormwater consists of suspended material carried by the flow of the surface run-off from high to low portions (25). Besides that, also household wastes that are disposed of haphazardly and include decomposition processes in the soil dissolve with stormwater. Turbidity is also influenced by the presence of the objects mixed or objects colloid in the water. Turbidity is caused by materials or suspended particles that range in size from small colloidal to materials coarse discontinued that range from the scope of small colloidal to rough stuff. Turbidity can be generated from a physical process of mechanical and chemical such as sedimentation and decomposition. Turbidity also makes a real difference in terms of aesthetics and in terms of the quality of the water itself (7). The results of the research of Syarifudin and Santoso in lowering the value of turbidity is known that the water used has a value of turbidity without treatment within 35,7 NTU, after the managed method sieve the rice husk value is decreased until it reaches the 0.95 NTU, from research it is known that factors affecting the decline are the level of thickness of the filter material of carbonized rice husk (7).

Coli bacteria in stormwater run-off were originating from manure and organic waste contained in the soil that can enter into the flow of rainwater. The human factor and the animals influence the presence of the Coli bacteria. Coli bacteria generated from biological processes resulting from the process of provision of fertilizer and animal manure. The water containing the Coli bacteria is thought to have been polluted by dung. The Coli bacteria is used as an indicator of determining whether water has become tainted by feces because it is more resistant to life on the condition of the environment compared to other pathogenic bacteria (6).

Research result from Syarifudin in managing Coli bacteria in water with a carbonized rice husk filter is capable of dropping compared with the water before processing, and this can be seen from the findings of Coli bacteria before the treatment of 21,333 colonies, after being managed, the best-known results for various variations in the thickness of the carbonized rice husk filters can lower up to 110 colonies, in standard quality still inappropriate because only up to 50 colonies of 100 ml of the bacteria can do so they can decrease the thickness Coli bacteria to reach the quality required for human beings (6). In addition to what Syarifudin has reported, the effectiveness of rice husk charcoal in reducing turbidity, microorganisms, and other pollutants has been widely reported. The summary can be seen in the following Table 4.

**Table 4.** The effectiveness of carbonized rice husks to removal turbidity and Coli bacteria.

| Method | Removal Pollutant | Source |
|---|---|---|
| Two-stage purification | – Turbidity : 90-95%<br>– Total Coliform (Coli Bacteria) : 90-95% | (26) |
| The laboratory-scale filtration tests | – Turbidity : 95% | (27) |
| Natural coagulants | – Turbidity : 96% | (28) |
| Gravity sand filtration with carbonized rice husk | – Turbidity : >65% | (29) |
| Filtration, combined sand (0.7-1.3mm) and carbonized rice husks in 1:1 proportion | – Turbidity : 98.97%<br>– Hardness : 12.19%<br>– Color : 90.63% | (30) |
| Used as adsorbent | – Turbidity : 98,2%<br>– COD : 88%<br>– TSS : 80%<br>– Colour : 95% | (31) |
| Gravity sand filtration with carbonized rice husk | – Turbidity : >65% | (32) |
| Ceramic membrane with 20% rice husk combination | – Total Coliform (Coli Bacteria) :93-96% | (33) |
| Used as adsorbent | – Turbidity : 95% | (34) |

*3.4. SEM Analysis*

According to the research that the carbonized rice husk activated at 700-degree Celcius indicates the carbonized rice husks have huge pores (Figure 2) (35). With this, it can be assumed that the carbonized rice husk absorbs turbidity and Coli bacteria. In conjunction with the research, Adediran et al. stated that most of the carbonized rice husks had the content of Silica (Si) (Figure 3) (36). These elements of Si existed significantly in the adsorbs of pollutants from stormwater.

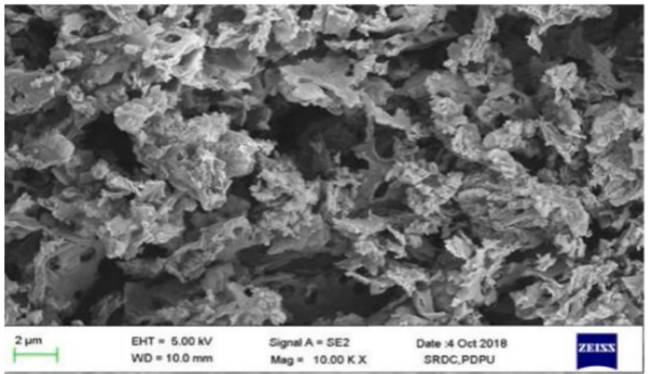


**Figure 2**. SEM (35).

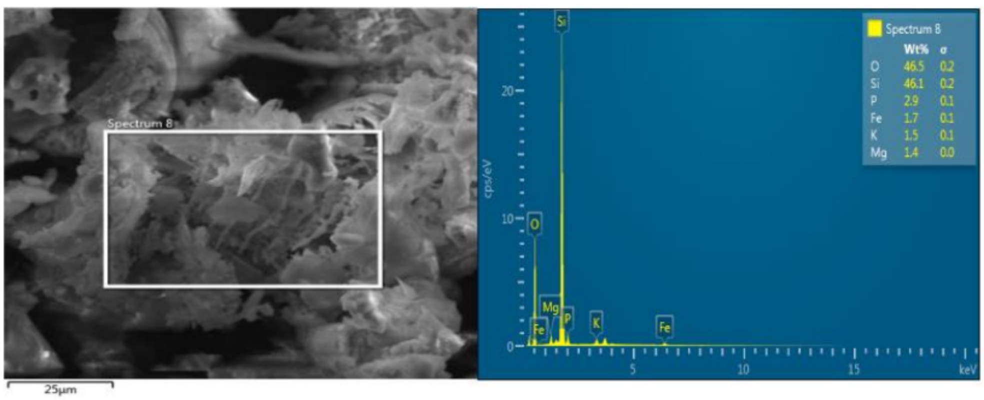


**Figure 3.** SEM image representative and EDX (36).

## 4. Conclusion

The rain garden is a natural expanse like a garden comprising a combination of soil and leaves and plants. A rain garden is also called a bio resistant area, in which it is designed to temporarily hold stormwater, filters and it helps the infiltration and evaporation process. The rice husk carbonized barriers were alternative media filter rain gardens to degrade the plot's value and the number of Coli bacteria, as it has large pores and contains the fertility of the superior. Based on the results of the study, carbonized rice husk can be removed from turbidity and Coli bacteria. The efficiency rate decreased turbidity between 65%-99%, while the decrease in Coli bacterial between 90-96%. The Rain Garden with filter rice husk carbonized is expected to be a new idea in the management of stormwater to decrease the value of turbidity and also Coli bacteria to be able to increase the effectiveness of its control to be researched further.

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# Potential Of Carbonized Rice Husk As A Filter Media Rain Garden To Decrease The Turbidity Of Water And Coli Bacteria In The Stormwater Runoff. A Review Of Current Research

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