Portable wastewater treatment plant using banana stem filter media in small scale motor vehicle washing services

Y Kusumawardani*, S Subekti, W Astuti, and S Soehartono
Engineering Faculty Pandanaran University, Semarang, Indonesia

*Email: yustika@unpand.ac.id

Abstract. One of the technology that can be applied to small-scale wastewater treatment was used simple filtering system. In general, water filter media uses a mixture with layered system such as silica sand media, zeolite, manganese green sand, and activated carbon. Portable WWTP can be used for effective and efficient motorized vehicle washing wastewater treatment so that the wastewater was environmentally friendly and can be reused. The variables used in the design test are TSS, Detergent and pH. Filter media that used were banana stem, zeolite sand and activated carbon with a thickness of 50 cm, a downflow-upflow flow and a duration of 3 days. The results showed that the average percentage of effectiveness after going through IPAL were 31% BP-BP (banana stem-banana stem), 46% BP-PK (banana stem-sand carbon), and PZ-KA (zeolite-activated carbon) by 48%. The use of banana stem filters was considered more economical, easy to obtain, fast, lightweight and practicable. Banana stem filter media was also more effective in lowering pH. The use of variety banana stem filter media with a combination sand and carbon (BP-PK) can minimize the weakness of the sand filter, which generally requires a long flow time and sufficient pressure.

1. Introduction
River water has an important function in meeting various needs of the community, including as a source of clean water, water transportation, and a center for business activities. In line with efforts to improve community welfare, the development of the area around the river to fulfill various needs continues to increase. Likewise with small-scale motorized vehicle washing services, which are currently widely available on riverbanks. Motor vehicle washing wastewater that is discharged directly into water bodies in large quantities can cause pollutant levels increase [1]. Increasing the level of pollution in water bodies, especially river water, will certainly worsen the quality of the environment.

One of the alternatives for waste treatment for motor vehicle washing activities is to use a filtration system. Filtration is the process of purifying or filtering wastewater through filter media or porous materials to remove suspended fine solids and colloids [2]. In general, water filter media uses a mixture with a layered system such as silica sand media, zeolite, manganese green sand, and activated carbon media. According to previous research, banana stem filter media has positive potential in motorized vehicle waste water treatment, where banana stem filter media can reduce TSS and detergent impurity parameters [5].

The choice of technology or wastewater treatment equipment must consider several things, including the quantity of waste to be treated, the expected water quality, ease of management, availability of land and energy sources, and operating and maintenance costs [1]. Efforts to treat waste from motorized vehicle washing activities have generally not been carried out by small-scale...
motorbike washing service entrepreneurs because in manufacturing wastewater treatment plants it usually requires complex land and processing installation mechanisms. In addition, business activity managers often apply a contract system or lease a place or land for motor vehicle washing business activities. Based on field conditions, a portable wastewater treatment plant (IPAL) is required.

Each type of equipment or wastewater treatment plant has its own advantages and disadvantages, therefore in the selection of tools and installation, it is necessary to pay attention to the technical aspects, economic aspects and environmental aspects, as well as human resources who will operate and manage these facilities [3]. The design of the portable WWTP aims to increase operating and cost efficiency. Portable WWTP has advantages in terms of lightweight materials, easy to manufacture and operate [4]. The use of portable IPAL can be used for waste treatment in motorized vehicle washing business activities that are effective and efficient so that the waste water was environmentally friendly and can even be processed for reuse.

The main objective of this research is to design a wastewater treatment plant using banana stem filters and to determine the effectiveness of the wastewater treatment plant in reducing test parameters. Meanwhile, the target obtained was the existence of motorized vehicle washing waste water treatment technology that can overcome environmental pollution.

2. Materials and Methods
The research was conducted by making a portable wastewater treatment plant. The preparation of banana stem filter media and other comparable filter media that commonly used is in the form of zeolite gravel filter media and activated carbon. The research dependent variable used in the design test for this Portable Wastewater Treatment Plant (IPAL) was the concentration of TSS, Detergent and pH. Banana stem filter media, sand filter media and activated carbon with a thickness of 50 cm each. The flow system used is the downflow upflow flow. Sample testing is done by analyzing the pH value, TSS content and detergent. Water sampling was carried out for 3 consecutive days to determine the durability of the banana stem filter media in treating wastewater. The calculation of the effectiveness of parameter reduction is as follows:

\[ E = \frac{(Co - C)}{Co} \times 100\% \]

Where: \( Co \) = initial concentration and \( C \) = final concentration

![Figure 1. Detailed sketches of Portable WWTP](image)

a. Banana stem-banana stem (BP-BP)
b. Zeolite-activated carbon (PZ-KA)
c. Banana stem-sand carbon (BP-PK)
3. Results and discussion
Liquid waste generated from motor vehicle washing businesses generally contains TSS and other waste materials that are harmful to the environment [21]. The wastewater of motor vehicle washing service was generally disposed in surrounding water bodies such as rivers or water gutters. According to the Regulation of the Ministry of Environment and Forestry or PERMENLHK No. P.68 of 2016 concerning Domestic Wastewater Quality Standards, the test parameters of waste water used for washing motor vehicles still exceed the quality standard. The concentration of wastewater from motorized vehicle washing places before being treated is as shown in table 1.

Table 1. Concentration of TSS, Detergent and pH of Motor Vehicle Washing Wastewater

| Parameters | Wastewater days to-1 | 2 | 3 | Threshold Value |
|------------|----------------------|---|---|-----------------|
| TSS        | 306                  | 306 | 358 | 30              |
| Detergen   | 89.7                 | 89.7 | 276 | -               |
| Ph         | 8.0                  | 8.0 | 8   | 6-9             |

The research data on the concentration of test parameters in motor vehicle washing wastewater samples after going through Portable IPAL with various types of filter media are as Table 2.

Table 2. Concentration of Test Waste Parameters after going through Portable IPAL (ppm)

| Variation | BP-BP | BP-PK | PZ-KA |
|-----------|-------|-------|-------|
| Days to   | 1     | 2     | 3     | 1     | 2     | 3     | 1     | 2     | 3     |
| TSS       | 138   | 228   | 184   | 55    | 196   | 63    | 45    | 204   | 40    |
| Detergen  | 36.3  | 85.5  | 129   | 8.55  | 51.7  | 107   | 34.6  | 44.9  | 9.81  |
| pH        | 7.22  | 6.9   | 7.06  | 7.58  | 7.49  | 7.04  | 7.7   | 7.56  | 7.69  |
3.1. WWTP of Variety of Banana-Stem Banana Stem Filter Media (BP-BP)

The design of this portable IPAL focuses on the effectiveness of selecting and using banana stem filter media in portable IPALs for small-scale motorized vehicle washing service businesses. The following is a graph of the results of the IPAL outlet sampling test.

![Variation BP-BP](image)

**Figure 3.** The effectiveness of decreasing test parameters on portable WWTP with a variety of banana stem-banana stem (BP-BP) filter media.

Based on the research data using portable IPAL with a comparison of the banana stem-banana stem (BP-BP) filtration media, it was considered passably in reducing the TSS, detergent and pH test parameters with an average value of 31%. Seeing the diagram image above, the best percentage reduction is 60% in detergent parameters on the first day. From the test results on the first day also showed a better% effectiveness of the decrease, compared to the other days.

The results of processing the portable wastewater treatment for motorized vehicle washing wastewater to reduce the TSS parameter showed a fairly good percentage with an average of 43%. From the 3 days of testing time, the sample on the first day of the efficiency of 55% showed better results than the following day. So that the longer used of banana stem filter media does not have a significant effect on the decrease in TSS parameters. Banana stem filter media can also process and reduce the detergent content in wastewater by 60% on the first day. Meanwhile, the pH value changes but is not very significant. The pH value of the outlet ranges from 6.9 to 7.22, from the pH of the original wastewater of 8. Banana stalks can reduce the pH value [1]. However, the value of decline over time is not very significant.

Seeing from Figure 3 the graph above shows that WWTP with media variations only banana stems (BP-BP) is quite effective in processing and decreasing the impurity test parameters on day 1 or continuously. The use of banana stem filter media directly (continuously) without immersion for a long time can provide an alternative technology for wastewater treatment using banana stem filter media [5]. Banana stems can be used as filter media because they contain cellulose and high hygroscopic abilities. The high cellulose content allows it to be used as an absorbent medium [7]. Banana stems also have a vascular bundle system consisting of phloem and xylem vessels which are scattered [8]. Therefore the TSS and detergent test parameters are filtered through the vessel system in banana stems.
3.2. WWTP of Variety of Zeolite-Activated Carbon (PZ-KA) Sand Filter Media

The ideal media for medium filters was media that has a large surface area per tub volume, cheap, durable, and it’s was not prone to clogging [9]. The filter media commonly used in filtration systems was sand, one of which is zeolite sand. Zeolite sand functions to remove the physical properties of water, such as turbidity / muddy water and removes odors in water. According to Artiyani (2016) research, sand is used at an early stage as a filter in processing dirty water into clean water [9]. Slow sand filters are more suitable for treating raw water, which has moderate to low turbidity, and moderate to high dissolved oxygen concentrations [18]. The following is a graphic image of the analysis results of the waste water outlet after filtering through WWTP.

![Variation PZ-KA](image)

**Figure 4** The effectiveness of decreasing test parameters on portable WWTP with variations of zeolite-activated carbon (PZ-KA) sand filter media

Based on the results of the study, it was found that the percentage of efficiency of reducing the test parameters was very good for the detergent parameters, namely 96% and TSS of 89% on the third day. Meanwhile, the pH parameter does not have a significant effect with a range of 4% -6% from the ph value of 8 to the range of the pH value of the outlet of 7.56-7.7. The longer the test day, the better the percentage of efficiency in reducing wastewater. One of the simple, cheap and easy to operate technologies suitable for wastewater treatment was the use of a sand filter [10]. It is believed that slow sand filters can reduce pollutant levels in car wash waste [11]. Meanwhile, activated carbon filter media is a material that has large pores and can absorb anything in its path [12]. Activated carbon is also often used in combinations or variations of water filtration.

In this study, variations of zeolite sand and activated carbon media were used as a comparison material to determine their effectiveness and efficiency. From the results of the outlets and the graph above, the percentage of PZ-KA variations does show good results, but for the pH value it doesn't really matter. But in practice, the speed of the filtration filter with sand and activated carbon media is quite slow, so it requires a large enough space. According to the results of previous studies, sand filters are prone to deadlock when the turbidity of raw water is high [13]. In addition, according to Cheremisinoff (2002) the weakness of sand filters is that the formation of a biofilm layer is disturbed if the water quality is contaminated with toxic compounds, and it is not flexible in 4 seasons because it will freeze in winter.
3.3. WWTP of Variety of Banana Stem-Carbon Sand (BP-PK) Filter Media

Sand filter media was a filter media that was commonly used in filtration systems, although it has several disadvantages, namely that it requires sufficient pressure or a large space so that the processing system can flow smoothly and continuously the flow rate. Selection and use of banana stem filter media, a combination of zeolite sand and activated carbon, is used to overcome or minimize these weaknesses in the application of portable WWTP. The following was a graph of the results of the IPAL outlet sampling test.

![Variation BP-PK](image)

**Figure 5.** The effectiveness of decreasing test parameters on portable WWTP with variations in banana stem - carbon sand (BP-PK) filter media

Based on the results of the graph analysis above, it shows passably decrease in parameters in all test parameters. The best efficiency percentage is 90% on detergent parameters on the first day. The average reduction in test parameters is around 46% better than the variation of banana stem filter media alone. In the bar chart figure 5, it also shows that the effectiveness of reducing its parameters is more stable until day 3, but still shows quite good results.

Total Suspended Solids (TSS) were solid materials such as sand, mud, soil and heavy metals suspended in water due to soil erosion or soil erosion that is carried into water bodies [6]. The decrease in TSS parameters by 82% on day 1 and 3 indicates that the use of a combination medium between banana stalks, seolite sand and activated carbon can have an effective effect. The hygroscopic nature of banana stems serves to absorb harmful inorganic chemicals in water media [14].

The use of banana stem filters is effective in a limited period of 1-2 days. While the sand filter tends to show effectiveness the longer the time the more effective it is to reduce its parameters. Banana stalks are used because they see the ease, availability, and economics around. In this study using banana stem filter media the percentage of pH reduction was quite good with banana stem filter media compared to other filter media. The pH value during the filtration process ranges from 8-7.04 where this value was alkaline and normal. The pH value of water was used to express the condition of wastewater if it is acidic if it is less than 7, alkaline if it is less than 7, and neutral if it was indicated by the number 7 [15].

The results of previous studies stated that the quality of wastewater after soaking with banana stems decreased pH and increased conductivity along with the length of contact time. This decrease in pH is thought to have occurred in the protonation of the active acid groups of banana stems from organic waste [16]. The pH value in the waste can reflect the balance between acids and bases in the
waste [17]. Domestic wastewater usually has a pH close to neutral [18]. Low pH values actually do not indicate good water quality. Because the standard or quality standard for good water quality is at normal pH or 7 [1].

3.4. The effectiveness of Portable WWTP

| Parameters | Day 1 | Day 2 | Day 3 | Average |
|------------|-------|-------|-------|---------|
| BP-BP      |       |       |       |         |
| TSS        | 55%   | 25%   | 49%   | 43%     |
| Deterjen   | 60%   | 5%    | 53%   | 39%     |
| PH         | 10%   | 14%   | 12%   | 12%     |
|            | 41%   | 15%   | 38%   | 31%     |
| PZ-KA      |       |       |       |         |
| TSS        | 85%   | 33%   | 89%   | 69%     |
| Deterjen   | 61%   | 50%   | 96%   | 69%     |
| PH         | 4%    | 6%    | 4%    | 4%      |
|            | 50%   | 30%   | 63%   | 48%     |
| BP-PK      |       |       |       |         |
| TSS        | 82%   | 36%   | 82%   | 67%     |
| Deterjen   | 90%   | 42%   | 61%   | 65%     |
| PH         | 5%    | 6%    | 12%   | 8%      |
|            | 59%   | 28%   | 52%   | 46%     |

The data analysis of the percentage of effectiveness as shown in the table above shows that the average percentage reduction in all test parameters for each variation is BP-BP by 31%, BP-PK 46%, and PZ-KA by 48%. The results of the analysis showed that the use of banana stem filters was considered more economical, easy to obtain, lightweight and practical to use. Filter media using banana stem was also more effective in decreasing pH parameters than variations in sand filter media. The use of a banana stem filter in combination with sand and carbon (BP-PK) can minimize the weakness of sand filters which generally require a long flow time or sufficient pressure with the result that the percentage of its effectiveness is not much different from the effectiveness of sand and activated carbon (PZ-KA) filters. According to research analysis data, the used of banana stem filter media as a portable IPAL filter media was the most effective on the first day with the best percentage on average of 59%. The content of organic matter in wet banana stems can remove pollutants in motor vehicle washing waste water [20].

4. Conclusion
Portable WWTP for small-scale motorized vehicle washing services using banana stem filter media was quite effective in reducing TSS concentrations, detergents and pH values. The best percentage of effectiveness reduction was 90% in detergent parameters on the first day of the BP-PK variation, combination banana stems with sand and carbon filters. From the test results for 3 days, the percentage
of the effectiveness of the reduction in the best test parameters after going through the respective WWTP was the variation of BP-BP by 31%, BP-PK 46%, and PZ-KA by 48%.

The use of banana stem filters was considered more economical, easy to obtain, lightweight and practice. Filter media using banana stems also more effective in decreasing pH parameters than variations in sand filter media. The use of a banana stem filter in combination of sand and carbon (BP-PK) can minimize the weakness of the sand filter, which generally requires a long running time or sufficient pressure.

Acknowledgements
The author would like to thank the Ministry of Research, Technology and Higher Education for the financial assistance that has been provided through the Beginner Lecturer Research Grant program and LPPM Pandanaran University so that this research can be carried out well.

Reference
[1] Y Kusumawardani, S Subekti, dan Soehartono 2019 Pengaruh Media Filter Batang Pisang terhadap pH dan TDS pada Pengolahan Air Limbah Pencucian Kendaraan Bermotor. Proc. of National Seminar on Biology 7th 2019, 18-24.
[2] Rahayu A, Masturi M, & Yulianti I 2015 Pengaruh Perubahan Massa Zeolit Terhadap Kadar Ph Limbah Pabrik Gula Melalui Media Filtrasi. Jurnal Fisika 5(2).
[3] Tim Direktorat Bina Pelayanan Penunjang Medik dan Sarana Kesehatan 2011 Pedoman Teknis Instalasi Pengolahan Air Limbah dengan Sistem Biofilter Anaerob Aerob Pada Fasilitas Pelayanan Kesehatan. Kementerian Kesehatan RI Direktorat Jenderal Bina Upaya Kesehatan, Jakarta
[4] Pamungkas B K 2015 Perencanaan IPAL Portable Dengan Untuk Pengolahan Anaerobic Biofilter Dan Aerobic Biofilter Untuk Kegiatan Usaha Bakery Di Kota Surabaya (Doctoral dissertation, Institut Teknologi Sepuluh Nopember).
[5] Y. Kusumawardani, S. Subekti, dan Soehartono 2019 Potensi dan Pengaruh Batang Pisang sebagai Media Filter pada Pengolahan Air Limbah Pencucian Kendaraan bermotor. Jurnal Presipitasi, 196-204.
[6] Muchlisin A 2012 Pemetaan Muatan Padatan Tersuspensi menggunakan Data Satelit Landsat (studi kasus: Teluk Semangka). Jurnal Penginderaan Jauh 9(1) 67-75
[7] Nugroho R A 2014 Ipteks Bagi Masyarakat Pondok Modern Gontor Putri 3 dalam Memanfaatkan Buangan Air Wudhu Santri untuk Budidaya Lele Dumbo dalam Terpal, Upaya Menuju Pesantren Berbasis Kewirausahaan. Fakultas Perikanan dan Ilmu Kelautan, Universitas Diponegoro.
[8] Intiro I A 2013 Kandungan Protein, Level Triptofan, dan Aktivitas Enzim Dehidrogenase pada Setiap Tingkat Kematangan Buah Pisang Ambon (Musa paradisiaca var. sapientum). Skripsi. Universitas Lampung.
[9] Artiyan A & Firmansyah N H 2016 Kemampuan Filtrasi Upflow Pengolahan Filtrasi Up Flow dengan Media Pasir Zeolit dan Arang Aktif dalam Menurunkan Kadar Fosfat dan Deterjen Air Limbah Domestik Industri Inovatif: Jurnal Teknik Industri 6(1) 8-15
[10] Maryani D, Masduqi A & Moesriati A 2014 Pengaruh ketebalan media dan rate filtrasi pada sand filter dalam menurunkan kekeruhan dan total coliform Jurnal Teknik ITS 3(2), D76-D81.
[11] Chrisafitri A & Karnaningroem N 2012 Pengolahan Air Limbah Pencucian Mobil dengan Reaktor Saringan Pasir Lambat dan Karbon Aktif Prosiding Seminar Nasional Manajemen Teknologi XVI 14.
[12] Roop C B & Meenakshi G 2005 Activated carbon adsorption CRC PressTaylor & Francis Group, NW, FL.
[13] Kusumawardani Y 2014 Rekayasa pola perilaku dinamik kinerja lapisan schmutzdecke pada saringan pasir lambat(Doctoral dissertation, Institut Teknologi Sepuluh Nopember).
[14] Edahwati L 2012 Sulphate Potassium Extraction from Banana Stem Ash with Bleaching Earth Waste Liquid Teknik Kimia 4(2).
[15] Widayatno T & Sриyani S 2008 Pengolahan Limbah Cair Industri Tapioka dengan menggunakan Metode Elektroflokulasi Jurnal Fakultas Hukum UII.
[16] Natanael C L & Sulaiman A P 2015 Respon Air Olahan Limbah Cantinamipa dengan Perendaman Batang Pisang dan Ampas Teh Terhadap Tanaman Mangkokan. Chimica et Natura Acta 3(1).
[17] Doraja P H, Shovitri M & Kuswytasari N D 2012 Biodegradasi limbah domestik dengan menggunakan inokulum alami dari tangki septik. Jurnal Sains dan Seni ITS 1(1) E44-E47.
[18] Quddus R 2014 Teknik pengolahan air bersih dengan sistem saringan pasir lambat (downflow) yang bersumber dari Sungai Musi (Doctoral dissertation, Sriwijaya University).
[19] Adella M. 2017 Penggunaan Ipal Portable Dalam Menyisihkan Kandungan Tss, Tds Serta Nitrat (No3) Pada Limbah Domestik Di Kawasan Kantin Teknik Elektro Universitas Diponegoro Semarang (Doctoral dissertation, Universitas Diponegoro).
[20] SM, A. N. M. 2011 Kinetika Adsorpsi Karbon Aktif Dari Batang Pisang Sebagai Adsorben Untuk Penyerapan Ion Logam Cr (Vi) Pada Air Limbah Industri (Doctoral dissertation, Universitas Negeri Semarang).
[21] Mustofa D 2013 Dampak Kimia Usaha Pencucian Kendaraan Bermotor. Jakarta: FMIPA Universitas Terbuka.