Determination of the best flow direction in wastewater treatment for vehicle wash facilities using activated carbon filters

by Evi Afiatun

IOP Conference Series: Materials Science and Engineering

PAPER • OPEN ACCESS

Determination of the best flow direction in wastewater treatment for vehicle wash facilities using activated carbon filters

To cite this article: H Pradiko *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1098** 052029

IOP Conf. Series: Materials Science and Engineering 1098 (2021) 052029 doi:10.1088/1757-899X/1098/5/052029

Determination of the best flow direction in wastewater treatment for vehicle wash facilities using activated carbon filters

H Pradiko*, L Mulyatna, E Afiatun and A F Heraudi

Environmental Engineering, Faculty of Engineering, Pasundan University, Jl. Dr. Setiabudhi No 193 Bandung, Indonesia

*harypradiko@unpas.ac.id

Abstract. Vehicle washing service is a commercial activities used detergent as supporting material to clean vehicles. The vehicle washing waste decrease the ground water and surface water quality. Water savings are needed trough recycling and fixing water quality. This study aims to determine the best flow direction in reducing the turbidity, surfactants, and COD concentration contained in the wastewater using an activated carbon filter with the filter diameter 10 cm, the activated carbon height 90 cm and the activated carbon grain in size >2 mm. The variation used in these research is: flow direction (bottom to top, top to bottom in submerged condition, and top to bottom without submerged condition); initial surfactants concentrations; and flow rate. The results showed that the best turbidity removal occur in the up to down direction in all discharge and concentrations variations which succeeded in removing turbidity 100%. The best surfactants removal occurs in the bottom to top direction with a discharge 0.0088 L/s which removed the surfactants 99.92%. The best COD removal occur in the top to down direction with submerged condition in discharge 0.0147 L/s which removed COD 67.45%. Each flow direction has difference mechanism and process to removal parameters.

1. Introduction

Vehicle washing service is one of the commercial activities that uses detergent as a supporting material for cleaning motorcycles and cars. But without realizing it, vehicle washing waste can cause environmental problems, namely water pollution caused by the constituent materials of detergents [1]. Vehicle washing services use a large quantity of water which become wastewater during the washing of vehicles. After the vehicle cleaning process, large quantities of wastewater are discharged into aquatic and terrestrial environments. Car wash activities leave contaminants like oil and grease, surfactants, detergents, phosphates, hydrofluoric acid, ammonium bifluoride products (ABF) etc. [2]. Oils-fats and detergents, including detergents that can biodegrade, can be harmful to fish, because they can reduce the oxygen content in the aquatic environment. Therefore, oil-fats and COD are the two main pollution parameters that must be a concern [3]. To recycle wastewater from vehicle washing, the condition is that there should be no dust, oil or grease in the recycled water [4]. Given the large amount of water wasted from vehicle washing facilities, reuse and recycling of vehicle washing wastewater is carried out in many countries as a sustainable solution to reduce overall urban water demand [5].

The characteristics of vehicle washing wastewater depend on the socio-economic structure of a country. A study conducted in Malaysia showed that vehicle washing wastewater had chemical oxygen demand (COD) ranging from 75 to 738 mg/L and turbidity of 34.7-86 NTU was reported. Another study in Brazil reported that vehicle washing wastewater contained COD 259 ± 40 mg / L and turbidity at 139 ± 45 NTU [4].

Surfactants contained in detergent are very difficult to decompose biologically. This will indirectly have an impact on the environment, especially water resources. Surfactants consist of 2 types, namely ionic and nonionic surfactants. Both are found in rivers in varying proportions ranging from 0.05-2.00 mg / l for ionic and 0.10-7.50 mg / l for nonionic. High surfactant concentrations in rivers are noted in the summer. In addition to vehicle washing services, surfactants are also used in households and industries every day in a variety of domestic, municipal and agro-industrial activities. From these various activities, surfactants flow into rivers or city sewers. Each type of surfactant has a different performance and destiny in the ecosystem that it enters [6]. The surfactants produce foam. The oxygen transferred from the air will be very slow due to the foam covering the water surface [7]. Processing of surfactants and oil-grease are very difficult, even though it uses filtration process like membrane technology [4]. In addition to using filtration, vehicle washing water treatment can use an adsorption process, where wastewater treatment by adsorption is an effective method for removing organic pollutants from wastewater [8].

Water problems caused by detergents require proper handling, so that the detergents would not pollute the environment and interfere with human health. According to the Regulation of the Minister of Health of the Republic of Indonesia No.32 of 2017 concerning environmental health quality standards [3-9], the maximum turbidity level is 25 NTU. Based on the Regulation of the Minister of Environment of the Republic of Indonesia No.5 of 2014 concerning the standard quality of wastewater [4-10], the maximum permissible surfactants (MBAS) concentration of 3 mg/L and the maximum allowable COD concentration level of 180 mg/L.

Wastewater treatment is the process of making wastewater suitable for use or restoring its original state [11]. All wastewater treatments make efforts to remove solids, bacteria, algae, plants and inorganic material [12]. Wastewater treatment methods such as coagulation, chemical oxidation, absorption and filtration are studied for use in the vehicle washing industry, but many of these methods require large costs [5]. Natural wastewater treatment technology is considered to be able to survive because of the low treatment costs, easy maintenance, longer processing time, and the ability of the treatment to recover various resources [13]. Filtration method is the simplest and cheapest treatment technology based on physical processes to treat wastewater contaminants such as color, odor, hardness, BOD, COD, and suspended solids. Multimedia filters can be used to improve the quality of processing results [14].

Based on the background of the problems outlined above, it is necessary to conduct research on wastewater treatment using grained media filter. The media used is activated carbon, which is relatively inexpensive and easy to obtain. Activated carbon is an amorphous carbon consisting of free carbon atoms and has an internal surface so that it has good ability in the adsorption process. The surface of activated carbon is relatively free of deposition and is able to absorb material due to its large surface area and open pores. The quality of activated carbon depends very much on its raw material, its basic properties, its absorption capacity and its molecular structure [15]. Activated carbon has beneficial adsorptive, catalytic, electrochemical and other properties. Activated carbon is used in treating water, wastewater and leachate. Activated carbon is used effectively in the adsorption of solutes from aqueous solutions [16]. Activated carbon can absorb microorganisms, pathogens, solutes and quickly develop biofilms [12]. The use of activated carbon is expected to reduce the concentration of turbidity, surfactants, and COD in vehicle washing wastewater. Activated carbon is the most efficient in removing wastewater turbidity and has been proven effective in removing COD, BOD, chloride, sulfate, turbidity and pH of wastewater [8]. Activated carbon can remove oil and grease concentration up to 30 mg/L [3]. Activated carbon can also remove COD and organic matter up to 75-80 percent. The advantages of activated carbon in wastewater treatment are 1) Very effective in removing non-polar organic chemicals in water 2) Can be used to process various kinds of organic compounds 3) Very effective in removing colors from wastewater 4) Effective in removing inorganic pollutants low level (ppb range) 5) Carbon thermal regeneration can destroy adsorbed solutes 6) A highly flexible system allows quick start-up and

IOP Conf. Series: Materials Science and Engineering 1098 (2021) 052029 doi:10.1088/1757-899X/1098/5/052029

shutdown as needed 7) The system can be designed portable, to be carried easily to waste water sources [17].

2. Research objectives

The purpose of this research is to provide an alternative treatment facility that is simple and efficient in treating vehicle washing wastewater, so that it is safer when discharged into the environmental.

3. Research methodology

3.1. Tools and materials

This research uses a cylindrical reactor with a diameter of 10 cm, height of 100 cm, and height of the media of 90 cm [18]. The media used is activated carbon with a size > 2 mm [19].

3.2. Method

This research is an experimental study using a mixed method, which combines quantitative methods and qualitative methods through several procedures to collect quantitative data and analyze these data qualitatively in a study or series of studies to understand the problem [20].

This research was carried out by measuring the level of turbidity, surfactants and COD concentrations present in vehicle washing wastewater at the time before and after passing the reactor tube containing activated carbon media. There are several variables that are influence the removal of turbidity, surfactants and COD concentrations. The variables are the initial surfactants concentration of artificial wastewater, flow direction, discharge, and contact time between the artificial waste water and the media in the reactor. The research flowchart can be seen in figure 1.

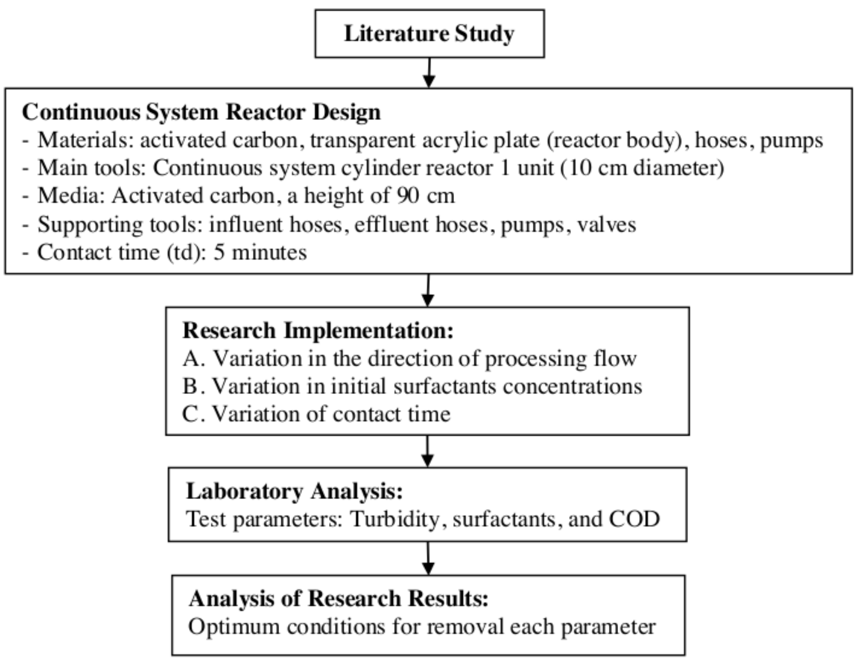
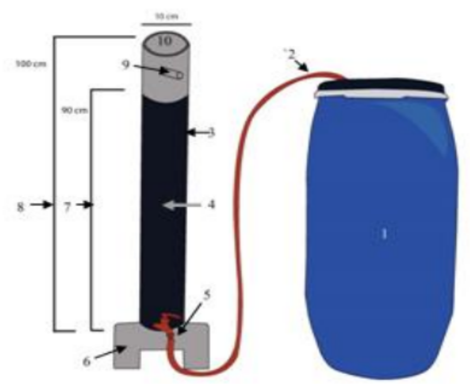


Figure 1. Flowchart of research stages.

IOP Conf. Series: Materials Science and Engineering 1098 (2021) 052029 doi:10.1088/1757-899X/1098/5/052029

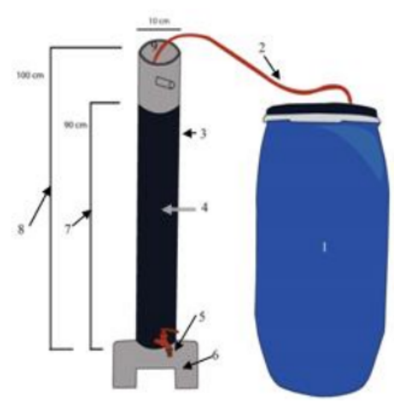
3.3. Research design

The research design used for the direction of the bottom-up (called Bottom-Up), the top to bottom with the condition of the media not submerged (called Top-Down Type 1), and top to bottom with the condition of the submerged media (called Top-Down Type 2) can be seen in the following picture.



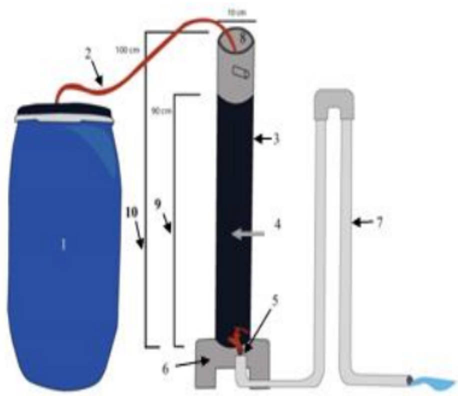
Information:
1. Wastewater tank
2. Hose in
3. Reactor tubes
4. Activated carbon
5. Inlet valve
6. Reactor holder
7. Media height
8. Reactor height
9. Outlet pipe
10. Reactor diameter

Figure 2. Bottom-up flow design.



Information:
1. Wastewater tank
2. Hose in
3. Reactor tubes
4. Activated carbon
5. Outlet valve
6. Reactor holder
7. Media height
8. Reactor height
9. Reactor diameter

Figure 3. Top-down type 1 flow design.



Information:
1. Waste water tank
2. Hose in
3. The reactor tube
4. Activated carbon
5. Outlet valve
6. Reactor holder
7. Outlet pipe
8. Reactor diameter
9. Media height
10. Reactor height

Figure 4. Top-down type 2 flow design.

3.4. Making artificial wastewater
The water used in this study is artificial waste water. The initial surfactants concentration variation in the artificial wastewater used was < 1 mg/L, 1-3 mg/L, and > 3 mg/L. This variation is chosen based on the condition of the original wastewater released from vehicle washing facilities which have been diluted by the use of a lot of water. The following are preparations for making artificial waste water:

- Wastewater is made by mixing: detergent used in vehicle washing facilities; tap water from the Water Laboratory of Unpas Environmental Engineering; and soil. This solution was mixed until the turbidity of the mixture reached 50.66 NTU (based on the turbidity of the original wastewater tested at the vehicle washing facility).
- Artificial wastewater with initial surfactants concentration < 1 mg/L is carried out by mixing 100 liters of tap water with 0.538 g of detergent and 60 g of soil.
- Artificial wastewater with an initial surfactants concentration of 1-3 mg/L is carried out by mixing 100 L of tap water with 5.04 g of detergent and 60 g of soil.
- Artificial wastewater with initial surfactants concentration > 3 mg/L is carried out by mixing 100 liters of tap water with 8,895 g of detergent and 60 g of soil.

3.5. Contact time
Determination of the contact time used is based on preliminary research that gets the optimum contact time of 5 minutes. To get better results, contact time is tried with variations of 5 minutes, 4 minutes and 3 minutes. Since the contact volume between water and media in the reactor has been determined, variations in contact time are applied by adjusting the flow rate. With a contact volume in the reactor of 2,650 L, the discharge for a 5-minute contact time is 0.0088 L/sec, for a 4-minute contact time is 0.011 L/sec, and for a 3-minute contact time is 0.0147 L/sec.

3.6. Measured parameters
The measured parameters in this research were turbidity, surfactants and COD concentration. Turbidity testing is carried out on the waste water that comes out of the reactor effluent every 5 minutes. If the turbidity test results are constant (marked by differences in the turbidity test results in wastewater <10%), the effluent water coming out of the reactor effluent will be taken to check the surfactants concentration and its COD parameters.

Turbidity testing was carried out using the Turbidimetry Method; examination of COD concentrations is carried out using the Closed Reflux with Titrimetry Method [21]; and ionic surfactants concentration checks were carried out using the Methylene Blue Active Substance (MBAS) Method [22].

4. Results and discussion

4.1. Create the calibration curve of MBAS solution

A calibration curve is a graph that states the relationship between the concentration of a standard solution and the absorbance of the solution measured on a spectrophotometer. The standard MBAS solution is made from a 1 liter Linear Alkylbenzene Sulfonate (LAS) main solution. Then from 1 liter of standard LAS solution, 10 ml is taken and diluted by adding 90 ml of distilled water until the volume reaches 100 ml to get the MBAS concentration of 100 mg / L. After that, the solution is diluted again to vary the solution with a surfactants concentration of 0.4; 0.8; 1.2; and 2.0 mg / L.

The solution was extracted according to the MBAS testing procedure and then analyzed using a UV-Visible spectrophotometer with a wavelength of 652 nm. Then the obtained data (table 1) is plotted into the graph to get the calibration curve (shown in figure 5).

Table 1. Absorbance of MBAS standard solution.

Standard Concentration (mg/L)	Absorbance
0.400	0.064
0.800	0.151
1.200	0.273
2.000	0.442

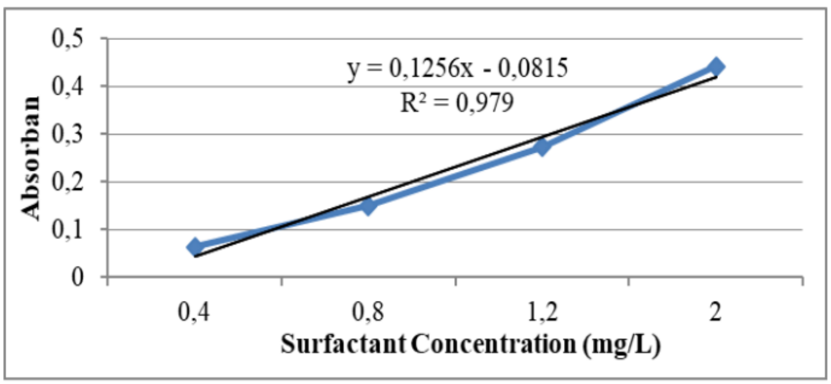


Figure 5. The calibration curve of MBAS standard solution.

Figure 5 shows that the absorbance value of the spectrophotometer measurement results has a good correlation with the concentration of the MBAS solution, so that the curves and line equations obtained can be used for the process of determining the surfactants content of the sample.

4.2. The results of bottom-up direction test

In this test, samples of artificial waste water with initial surfactants concentration variations <1, 1-3, and > 3 mg/L are processed through activated carbon media in the bottom-up flow direction. Furthermore, the turbidity level, surfactants and COD concentration contained in the sample of wastewater entering and exiting the reactor were measured. The results of this test can be seen in table 2 below.

Table 2. Turbidity test results in a bottom-up direction.

Contact Times (Minutes)	Initial Surfactants Concentrations (mg/L)	Sampling Times (Minutes)	Turbidity		
			Initial (NTU)	Final (NTU)	Removal (%)
5	<1	5	50.79	16.18[a]	68.14
		10		10.76[a]	78.81
		15		9.7[a]	80.90
		20		7.75[a]	84.74
		25[c]		7.12[c a]	85.98
		30		6.45[a]	87.30[b]
	1-3	5	52.26	22.3[a]	57.33
		10		20.13[a]	61.48
		15		18.08[a]	65.40
		20[c]		16.8[c a]	67.85
		25		16.38[a]	68.66
		30		15.87[a]	69.63[b]
	>3	5	49.56	19.89[a]	59.87
		10		16.75[a]	66.20
		15		10.74[a]	78.33
		20		7.23[a]	85.41
		25[c]		6.65[c a]	86.58
		30		6.09[a]	87.71[b]
4	<1	5	50.4	20.3[a]	59.72
		10		17.32[a]	65.63
		15		15.49[a]	69.27
		20		14.77[a]	70.69
		25		14.0[a]	72.22
		30[c]		14.8[c a]	70.63[b]
	1-3	5	49.94	12.81[a]	74.35
		10		10.17[a]	79.64
		15		8.58[a]	82.82
		20		8.08[a]	83.82
		25		7.8[a]	84.38
		30[c]		7.23[c a]	85.52[b]
	>3	5	51.36	16.63[a]	67.62
		10		11.29[a]	78.02
		15		10.39[a]	79.77
		20		8.92[a]	82.63
		25		8.69[a]	83.08
		30[c]		8.18[c a]	84.07[b]
3	<1	5	50.89	22.83[a]	55.14
		10		15.92[a]	68.72
		15		13.16[a]	74.14
		20		11.89[a]	76.64
		25		10.83[a]	78.72
		30[c]		9.71[c a]	80.92[b]
	1-3	5	50.9	19.96[a]	60.79
		10		18.97[a]	62.73
		15		15.97[a]	68.62
		20		15.02[a]	70.49
		25		13.82[a]	72.85
		30[c]		13.2[c a]	74.07[b]
	>3	5	50.74	14.54[a]	71.34
		10		12.05[a]	76.25
		15		11[a]	78.32
		20		10.3[a]	79.70
		25		9.02[a]	82.22
		30[c]		8.87[c a]	82.52[b]

Note:
[a] Meet water quality standards
[b] The best percentage of turbidity removal for each discharge variation
[c] Sampling time for measuring surfactants and COD concentrations

The sampling time chosen to measure the reduction in surfactants and COD concentrations of wastewater coming out of the reactor effluent is a constant time in turbidity removal which is marked by the percentage of turbidity removal that tends to remain at 2 consecutive times.

Table 3 below shows the results of the removal of surfactants concentrations in the bottom-up flow direction.

Table 3. The results of surfactants removal in bottom-up flow direction.

Contact Time (Minutes)	Initial Surfactants Concentrations (mg/L)	Sampling Time (Minutes)	Surfactants		
			Initial (mg/L)	Final (mg/L)	Removal (%)
5	<1	25	0.514	0.002[a]	99.2
	1-3	20	2.516	0.002[a]	99.92[b]
	>3	25	3.997	0.069[a]	98.26
4	<1	25	0.514	0.018[a]	96.4
	1-3	25	2.516	0.029[a]	98.83[b]
	>3	30	3.997	0.276[a]	93.09
3	<1	30	0.514	0.038[a]	92.6
	1-3	30	2.516	0.038[a]	98.49[b]
	>3	30	3.997	0.347[a]	91.3

Note:
[a] Meet quality standards
[b] The best percentage of surfactants removal for each discharge variation

The best surfactants removal occurs at 5 minutes' contact time. This is due to the slow discharge of wastewater which cause the contact time between wastewater and activated carbon media becomes longer so that the process of adsorption by activated carbon becomes more optimal.

From table 3, it can be seen that activated carbon can reduce the initial surfactants concentration of 3.997 mg/L to 0.069 mg/L with removal percentage of 98.26%. These results indicate that when the equilibrium point is reached, the surface of the adsorbent has been filled with adsorbate.

Surfactants are long chain molecules that contain hydrophilic and hydrophobic moieties. The type of surfactant according to its manufacture is biosurfactant or synthetic surfactant. Both can be classified as ionic and nonionic according to their hydrophilic moieties. Biosurfactants are synthesized by microorganisms, plants, or animals, with critical micelle concentration (CMC). These biosurfactants are classified as glycolipids, lipopeptides, phospholipids, fatty acids, neutral lipids, polymers, and particulates. Synthetic surfactants can be nonionic or ionic molecules. Nonionic surfactants have non-ionized properties in aqueous solutions, lower CMC levels, higher surface tension reduction, and relatively constant properties in the presence of salt make these nonionic surfactants more suitable for soil remediation, although the presence of clays and organic matter might affect the level their adsorption rate. Ionic surfactants consist of anionic, cationic, and zwitterionic or amphoteric surfactants. Anionic surfactants usually have sulfate, sulfonate, or carboxylate moieties. The mechanism for adsorption of surfactants to solid substrates is ion exchange, which involves replacing the counter-ion adsorbed to the substrate from the solution with the same charged surfactant ion; ion pairing, which occurs through surfactant ions which absorb from the solution to the opposite charged adsorbent site which is not inhabited by counter-ions [23].

Adsorption has long been considered a very efficient method of water treatment because of its low cost and ease of operation [23]. But, if wastewater has a high concentration of pollutants, the adsorbent can no longer absorb [24]. The amount of activated carbon is an important parameter because it determines the capacity of activated carbon adsorbents. Adsorption of activated carbon is also controlled by its particle size, because smaller particles will have more surface area for the adsorption process [25]. Table 4 below shows the results of the reduction in COD concentrations in the bottom-up flow direction.

Table 4. The results of COD removal in bottom-up flow direction.

Contact Time (Minutes)	Initial Surfactants Concentrations (mg/L)	Sampling Time (Minutes)	COD		
			Initial (mg/L)	Final (mg/L)	Removal (%)
5	<1	25	98.5	40.13[a]	59.25[b]
	1-3	20	136.4	89.38[a]	34.47
	>3	25	110.4	52.8[a]	52.17
4	<1	25	98.5	60.19[a]	38.89[b]
	1-3	25	136.4	97[a]	28.88
	>3	30	110.4	72[a]	34.78
3	<1	30	98.5	82.08[a]	16.6
	1-3	30	136.4	98.8[a]	27.56[b]
	>3	30	110.4	81.6[a]	26.08

Note:
[a] Meet quality standards
[b] The best percentage of COD removal for each discharge variation

The best COD removal occurs at 5 minutes' contact time. This is due to the slower flow of water so that there is a waiting time for water to flow from the bottom to the effluent and the contact time of water with the media is longer so that the process of adsorption by activated carbon can be maximized.

4.3. The results of top-down type 1 direction test

In this test, wastewater samples with initial surfactants concentrations < 1, 1-3, and > 3 mg/L were processed through activated carbon media with a type 1 top-down flow direction. As a result, all turbidity of wastewater coming out of the reactor effluent from minutes 5 to 30 can be set aside (100% removal efficiency). These results can occur because the discharge used is small in each discharge variation and the process that occurs is not only adsorption but also filtration, so the turbidity removal process is more optimal. Sampling time for the measurement of surfactants and COD concentrations was obtained after two measurements of the turbidity level of the sample which were considered to be the same (constant). Table 5 below shows the results of examination of surfactants concentrations in the type 1 top-down flow direction.

Table 5. Surfactants test results in type 1 top-down flow direction.

Contact Time (Minutes)	Initial Surfactants Concentrations (mg/l)	Sampling Time (Minutes)	Surfactants		
			Initial (mg/L)	Final (mg/L)	Removal (%)
5	<1	30	0.710	0.195[a]	72.55
	1-3	30	2.432	0.119[a]	95.08[b]
	>3	30	3.778	0.217[a]	94.24
4	<1	30	0.710	0.307[a]	56.72
	1-3	30	2.432	0.224[a]	90.79
	>3	30	3.778	0.272[a]	92.8[b]
3	<1	30	0.710	0.399[a]	43.84
	1-3	30	2.432	0.251[a]	89.68[b]
	>3	30	3.778	0.464[a]	87.72

Note:
[a] Meet quality standards
[b] The best percentage of surfactants removal for each discharge variation

Based on table 5, the best surfactants removal occurs at 5 minutes' contact time. This is due to the slow flow of water so that wastewater has more opportunities to contact with activated carbon media, so that the process of adsorption by activated carbon can occur more optimally.

From table 5, it can be seen that activated carbon can reduce the initial surfactants concentration from 3.778 mg/L to 0.217 mg/L with a removal percentage of 94.24%. These results indicate that when the equilibrium point is reached, the surface of the adsorbent has been filled with adsorbate. If wastewater has a high concentration, then the adsorbent cannot be adsorbed anymore [24]. Table 6 below shows the results of COD testing in the type 1 top-down flow direction.

Tabel 6. COD test results in type 1 top-down flow direction.

Contact Time (Minutes)	Initial Surfactants Concentrations (mg/L)	Sampling Time (Minutes)	COD		
			Initial (mg/L)	Final (mg/L)	Removal (%)
5	<1	30	108	105.6[a]	2.22
	1-3	30	115.2	108[a]	6.25
	>3	30	117.06	76.8[a]	34.39[b]
4	<1	30	108	96[a]	11.11
	1-3	30	115.2	81.6[a]	29.16
	>3	30	117.06	62.3[a]	46.78[b]
3	<1	30	108	55.2[a]	48.89
	1-3	30	115.2	48[a]	58.33[b]
	>3	30	117.06	49.08[a]	58.07

Note:

[a] Meet quality standards

[b] The best percentage of COD removal for each discharge variation

Based on table 6, the decrease in COD concentration in the direction of top-down type 1 flow is inversely proportional to the decrease in surfactants concentration. The best decrease in COD concentration occurs at 3 minutes' contact time. This happens because at the 3-minute contact time the wastewater enters more quickly resulting in a collision between the wastewater and the media which causes the wastewater to be distributed more evenly at the reactor. This evenly distributed wastewater will provide opportunities for more wastewater to contact with the media. Conversely, if the flow of wastewater is slower, wastewater does not pass through all media, so the COD reduction only occurs in the media through which wastewater is passed.

4.4. The results of top-down type 2 direction test

The results of testing wastewater samples with variations in initial surfactants concentrations <1, 1-3, and> 3 mg/L, both before or after passing through the reactor, using the type 2 top-down flow direction for the turbidity levels obtained can be seen in table 7.

Table 7. Turbidity test results in a type 1 top-down flow direction.

Contact Time (Minutes)	Initial Surfactants Concentrations (mg/L)	Sampling Time (Minutes)	Turbidity		
			Initial (NTU)	Final (NTU)	Removal (%)
5	<1	5	50.44	0.00[a]	100.00 [b]
		10		1.94[a]	96.15
		20		7.25[a]	85.63
		30 [c]		6.69[a]	86.74
	1-3	5	50.72	0.00[a]	100.00 [b]
		10		8.73[a]	82.79
		20		10.48[a]	79.34
		30 [c]		10.17[a]	79.95
	>3	5	51.14	0.00[a]	100.00 [b]
		10		10.86[a]	78.76
		20		13.25[a]	74.09
		30 [c]		11.82[a]	76.89
4	<1	5	51.3	14.75[a]	71.25
		10		14.69[a]	71.36
		20		13.19[a]	74.29
		30 [c]		12.7[a]	75.24 [b]
	1-3	5	51.3	13.43[a]	73.82
		10		12.89[a]	74.87
		20		11.93[a]	76.74
		30 [c]		11.04[a]	78.48 [b]
	>3	5	51.61	19.05[a]	63.09
		10		17.18[a]	66.71
		20		16.44[a]	68.15
		30 [c]		15.85[a]	69.29 [b]
3	<1	5	50.45	16.81[a]	66.68
		10		15.46[a]	69.36
		20		14.69[a]	70.88
		30 [c]		14.39[a]	71.48 [b]
	1-3	5	51.3	18.52[a]	63.90
		10		17.78[a]	65.34
		20		13.46[a]	73.76
		30 [c]		12.66[a]	75.32 [b]
	>3	5	51.66	21.69[a]	58.01
		10		21.3[a]	58.77
		20		17.98[a]	65.20
		30 [c]		17.21[a]	66.69 [b]

Note:
[a] Meet water quality standards
[b] The best percentage of turbidity removal for each discharge variation
[c] Sampling time for measuring surfactants and COD concentrations

Sampling time for the measurement of surfactants and COD concentrations was obtained after two measurements of the turbidity level of the sample which were considered to be the same (constant). Table 8 below shows the results of examination of surfactants concentrations in the type 2 top-down flow direction.

Table 8. Surfactants test results in a type 1 top-down flow direction.

Contact Time (Minutes)	Initial Surfactants Concentrations (mg/L)	Sampling Time (Minutes)	Surfactants		
			Initial (mg/L)	Final (mg/L)	Removal (%)
5	<1	30	0.767	0.257[a]	66.49
	1-3	30	2.749	0.211[a]	92.3
	>3	30	5.551	0.088[a]	98.4[b]
4	<1	30	0.767	0.364[a]	52.54
	1-3	30	2.749	0.324[a]	88.19
	>3	30	5.551	0.493[a]	91.1[b]
3	<1	30	0.767	0.498[a]	35.07
	1-3	30	2.749	0.426[a]	84.48
	>3	30	5.551	0.579[a]	89.6[b]

Note:
[a] Meet quality standards
[b] The best percentage of surfactants removal for each discharge variation

Based on table 8, the best surfactants concentration removal occurred at 5 minutes' contact time. This is caused by the slow flow of water so that wastewater has more opportunities to contact with activated carbon media, so that the process of adsorption by activated carbon can occur more optimally.

From table 8, it can be seen that there has been a reduction in initial surfactants concentrations of 5.551 mg/L to 0.088 mg/L with removal efficiency of 98.4%. These results indicate that the direction of flow can be used to properly set aside surfactants concentrations. Table 9 below shows the results of measurements of COD concentrations in the direction of type 2 top-down flow direction.

Table 9. COD test results in type 2 top-down flow direction.

Contact Time (Minutes)	Initial Surfactants Concentrations (mg/L)	Sampling Time (Minutes)	COD		
			Initial (mg/L)	Final (mg/L)	Removal (%)
5	<1	30	108	105.6[a]	2.22
	1-3	30	115.2	108[a]	6.25
	>3	30	117.06	76.8[a]	34.39[b]
4	<1	30	108	96[a]	11.11
	1-3	30	115.2	81.6[a]	29.16
	>3	30	117.06	62.3[a]	46.78[b]
3	<1	30	108	55.2[a]	48.89
	1-3	30	115.2	48[a]	58.33[b]
	>3	30	117.06	49.08[a]	58.07

Note:
[a] Meet quality standards
[b] The best percentage of COD removal for each discharge variation

Based on table 9, the decrease in COD concentration in the type 2 top-down flow direction is inversely proportional to the decrease in surfactants concentration. The best decrease in COD concentration occurs at 5 minutes' contact time. The decrease in COD concentration in the type 2 top-down flow direction indicates that activated carbon can be used as an adsorbant to reduce the COD concentration in vehicle

IOP Conf. Series: Materials Science and Engineering 1098 (2021) 052029 doi:10.1088/1757-899X/1098/5/052029

washing wastewater. This is evidenced by the decrease in COD concentration after passing through the activated carbon media.

4.5. Comparison of variations in each parameter

The best turbidity removal and percentage graphs for all variations of discharge and flow direction can be seen in figures 6 and 7 below.

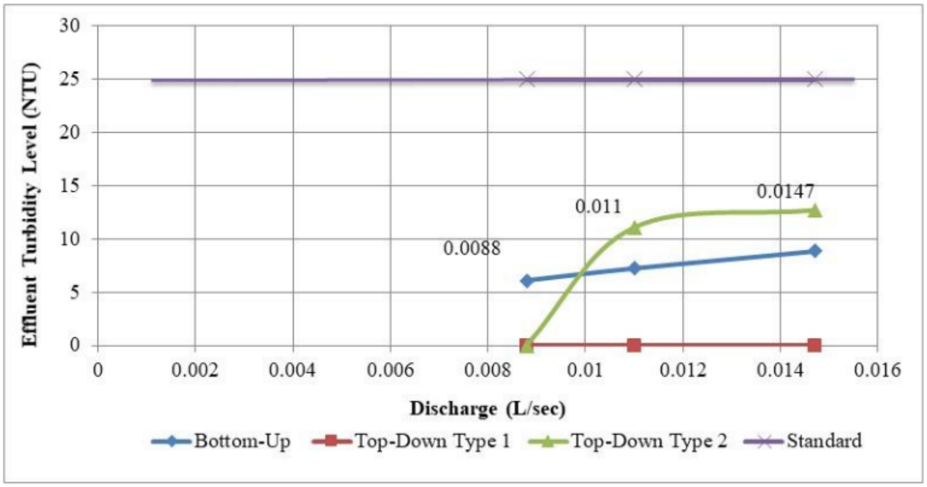


Figure 6. Best turbidity removal for all variations on discharge and flow direction.

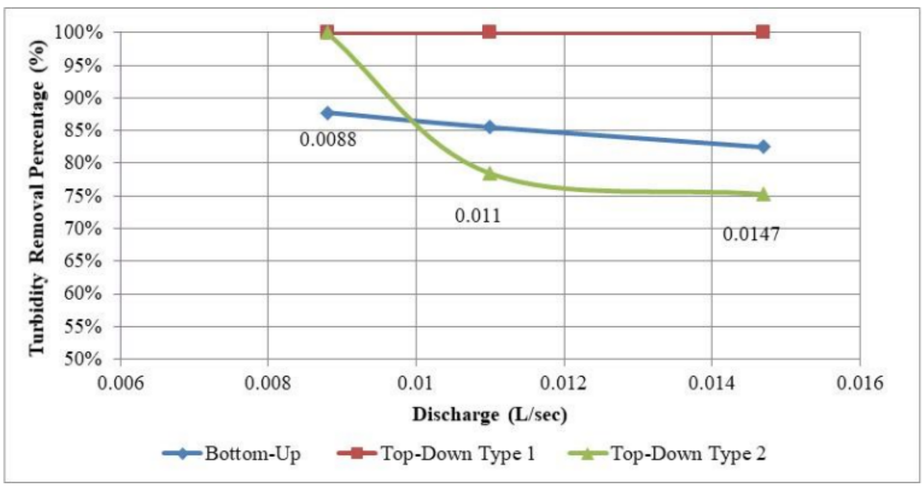


Figure 7. Best percentage of turbidity removal for all variations in discharge and flow direction.

From figure 6 and 7, it can be seen that the best turbidity removal occurs in the top-down flow direction for all variations of the test which succeeded in removing turbidity up to 0 NTU (100%) until the 30th minute treatment. The percentage of allowance of 100% can occur because the discharge that comes out in the direction of a small top-down flow in each variation of discharge and particles contained in wastewater can be removed by filtration or adsorption processes by activated carbon media. Activated carbon still has the ability to filter and adsorb turbidity in the range of 50.35-52.6 NTU because until the 30th minute treatment all tests produced good removal.

The best surfactants removal and percentage graphs in all variations of discharge and flow direction can be seen in figures 8 and 9 below.

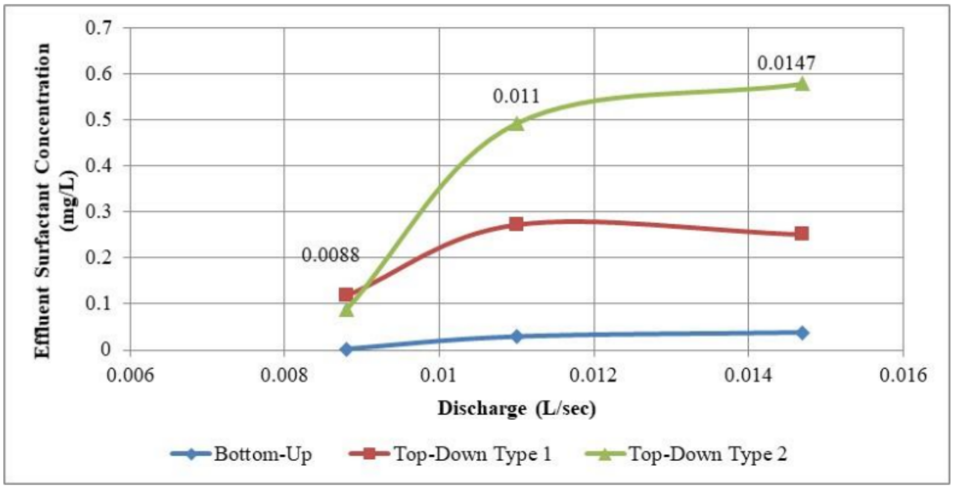


Figure 8. Best surfactants removal for all variations on discharges and flow direction.

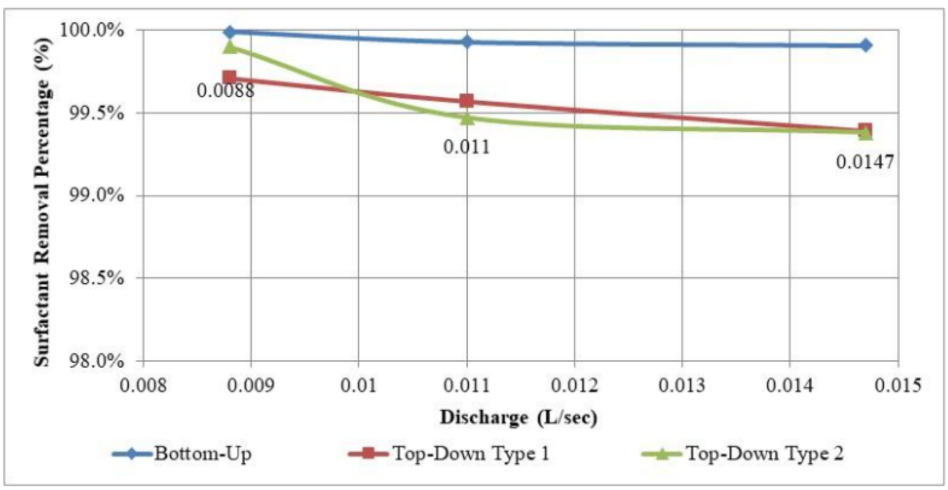


Figure 9. The best percentage of surfactants removal for all variations on discharge and flow direction.

From figures 8 and 9, a graph of surfactants removal in each flow direction shows that the smaller the discharge or the longer the contact time the greater the surfactants removal that occurs. Conversely, the greater the discharge or the faster the contact time the smaller the surfactants removal that occurs.

This can occur because smaller discharges or longer contact times lead to longer residence time of wastewater in the reactor, so that the physical absorption (adsorption) process in which the surface tensile force of the activated carbon media attracts and removes surfactants particles from wastewater [26]. Conversely, if there is greater disposal or faster contact time, the time for wastewater through activated carbon media will be faster so that the incoming surfactants do not have the opportunity to be bound and a portion of surfactants that have been bound to the surface of activated carbon will be released again. This condition causes desorption because the flow is fast and the adsorption process is not optimal.

The best surfactants removal occurs in the bottom-up flow direction at a rate of 0.0088 L / sec or a contact time of 5 minutes (sample taken at 25th minute) which succeeds in removing the initial surfactants concentration of 2.516 mg/L to become 0.002 mg/L (99,92%). The results of this study are in line with the results of research conducted by Andini which stated the best contact time with activated carbon media occurred at 5 minutes' contact time [19].

The best graph of COD removal and its presentation in all variations of discharge and flow direction can be seen in figures 10 and 11 below.

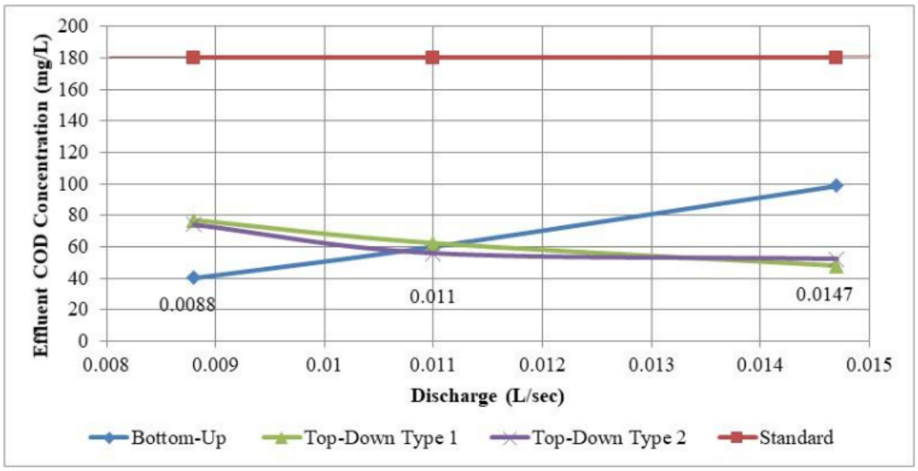


Figure 10. Best COD removal for all variations in discharge and flow direction.

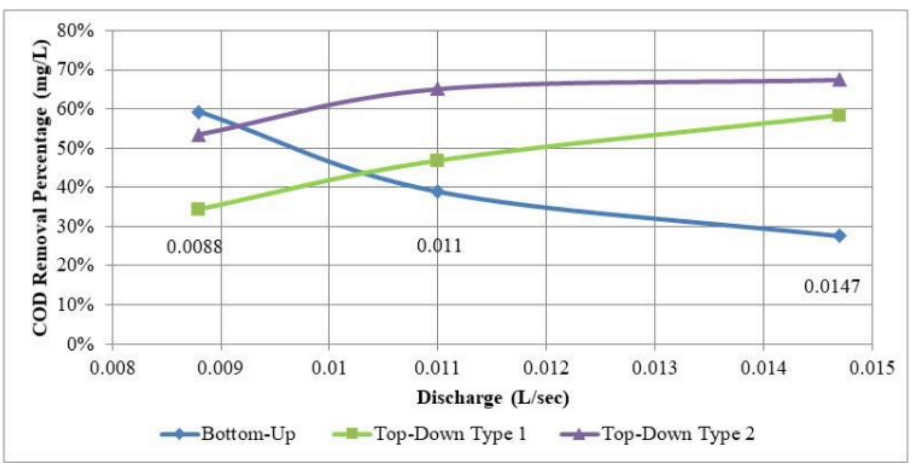


Figure 11. The best COD removal percentage from all discharge variations and flow direction.

From figures 10 and 11, the best COD concentration removal occurs in the direction of top-down type 2 flow with a flow rate of 0.0147 L/sec or a 3-minute contact time (sample taken at 30th minute) which successfully removes a COD concentration of 159.9 mg/L to 67.45 mg/L (67.45%). The smaller the discharge or the longer the contact time, the smaller the removal of COD concentration that occurs. Otherwise. the greater the discharge or the faster contact time, the greater the removal of COD concentration that occurs. This is because in the direction of the type 2 top-down flow of wastewater, most can be in contact with activated carbon so that the COD concentration can be reduced properly.

5. Conclusion

Based on the research data obtained. it can be concluded that The best turbidity removal occurs in the type 1 top-down flow direction for all discharge variations and all variations of concentration which successfully remove turbidity up to 0 NTU (100%) until the 30th minute. The best surfactants removal occurs in the bottom-up flow direction at a flow of 0.0088 L/sec or a contact time of 5 minutes (sample taken at 25th minute) with a decrease in initial surfactants concentration from 2,516 mg/L to 0.002 mg/L (99,92%). The best COD removal occurs in the type 2 top-down flow direction with a discharge of 0.0147 L/sec or a contact time of 3 minutes (sample taken at 30th minutes) at an initial surfactants concentration of < 1 mg/L which successfully decreases the COD concentration from 159, 9 mg/L to 67.45 mg/L (67.45%). All turbidity, surfactants and COD test results with variations in initial surfactants concentration, flow direction, and discharge have met the quality standards.

References

[1] Maretha A, Oktiawan W and Rezagama A 2014 Laundry waste treatment by addition of poly aluminium chloride (PAC) coagulant and activated carbon filter *J. Environmental Engineering* **3/4** 1-10

[2] Shafendy M S, and Hashim N H 2018 Characterization of car wash wastewater from manually dispersed, snow and auto car wash stations *Int. J. of Engineering & Technology* **7**(3.23) 45-48

[3] Mazumder D and Mukherjee S 2011 Treatment of automobile service station wastewater by coagulation and activated sludge process *Int. J. of Environmental Science and Development* **2**(1) 64-69

[4] Uçar D 2018 Membrane processes for the reuse of car washing wastewater *J. of Water Reuse and Desalination* **08**(2) 169-175

[5] Neerajasree V R, and Varsha Ashokan V 2019 Treatment of automobile waste water using plant-based coagulants *Int. Research J. of Engineering and Technology (IRJET)* **6**(06) 161-164

[6] Hassan F M, Al-Obaidy A H M J, and **Rana R. Al-Ani R R 2017 Detection of detergents (surfactants) in Tigris River- Baghdad/Iraq *Int. J. of Environment & Water* **6**(2) 1-15

[7] Connel and Miller 1995 *Chemical and ecotoxicological pollution* (Jakarta: Indonesia University Press) p 419

[8] Sunny N, Krishna S, Ghosh D, George D, and Kumar A M S 2019 Filtration of wastewater using natural adsorbents *Int. Research J. of Engineering and Technology (IRJET)* **6**(04) 4397-4400

[9] Regulation of the Minister of Health of the Republic of Indonesia No.32 of 2017 concerning Environmental Health Standards and Health Water Quality Standards (Jakarta: Directorate General of PP)

[10] Regulation of the Minister of Environment of the Republic of Indonesia No.5 of 2014 concerning Quality Standards for Liquid Waste (Jakarta: Directorate General of PP)

[11] Gnanaraj S C, Thankam G L, Mukilan K, and Nivetha K P 2019 Greywater treatment technologies *Int. J. of Engineering and Advanced Technology (IJEAT)* **9**(1S4) 425-430

[12] Tulip D R E 2017 Study on various technologies in wastewater treatment *Int. J. of Civil Engineering and Technology (IJCIET)* **8**(8) 1576–1580

[13] Dhote J, Ingole S, and Chavhan A 2012 Review on wastewater treatment technologies *Int. J. of Engineering Research & Technology (IJERT)* **1**(5) 1-10

[14] Islamuddin, Ahmad I, Ali N, and Mumtaz N 2016 Domestic wastewater treatment by low-cost

natural adsorbents *Int. J. for Scientific Research & Development* **4**(03) 1768-1771

[15] Haji A G, Pari G, Nazar M, and Habibati 2013 Characterization of activated carbon produced from urban organic waste *Int. J. of Science and Engineering (IJSE)* **5**(2) 89-94

[16] Tadda M A, Ahsan A, Shitu A, ElSergany M, Arunkumar T, Jose B, Razzaque M A, and Daud N N N 2016 A review on activated carbon: process, application and prospects *J. of Advanced Civil Engineering Practice and Research* **2**(1) 7-13

[17] Sanjay S, Akila E, Chavan A, Sunagad A, and Bhargavi B 2019 Adsorption in waste water using actvated carbon: a review *Int. J. of Advance Research and Innovative Ideas in Education* **5**(3) 1706-1712

[18] Pradiko H, Harahap M G, Mulyana L, Afiatun E, and Setiawan F 2019 *Proc. Int. Conf. on Sustainable Engineering and Creative Computing (ICSECC)* 259-264

[19] Andini D E 2019 *Vehicle washing waste water recycling using activated carbon reactors in a batch system* (Bandung: Department of Environmental Engineering, Pasundan University)

[20] Cresswell J W and Vicki L, Plano C 2008 *Designing and conducting mixed methods research.* (London: Sage Publications)

[21] SNI 06-6989.73-2009 2009 *Water and wastewater - Section 73: procedures for chemical oxygen demand (COD) tests with closed reflux in titrimetry* (Jakarta: National Standardization Agency)

[22] SNI 06-6989.51-2005 2005 *Water and wastewater - part 51: procedures for testing anionic surfactants levels with a methylene blue spectrophotometer* (Jakarta: National Standardization Agency)

[23] Tulip D R E 2017 Study on various technologies in wastewater treatment *Int. J. of Civil Engineering and Technology (IJCIET)* **8**(8) 1576–1580

[24] Sari I P and Widiastuti N 2010 *Proc. of Chemical*

[25] Indhumathi P, Shabudeen S P S, and Saraswathy C P 2011 The identification and characterization of activated carbon for adsorption studies *Int. J. of Advanced Engineering Technology* **2**(3) 78-84

[26] Heriyani O, and Mugisidi D 2016 *Proc. Nat. Conf. of TEKNOKA Vol. 1*

Determination of the best flow direction in wastewater treatment for vehicle wash facilities using activated carbon filters

ORIGINALITY REPORT

14%	14%	11%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

8%

★ M A R Ma'Bud, A R Djamaluddin, A A Amiruddin. "Correlation study of asphalt modulus with asphalt immersion time using of lightweight deflectometer laboratory", IOP Conference Series: Materials Science and Engineering, 2021

Publication

Exclude quotes	Off	Exclude matches	< 1%
Exclude bibliography	On		