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Removal of organic materials and coliform of domestic wastewater through soils

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ABSTRACT

Most densely populated housing in Surabaya is not served by sewerage system yet. Most of households in Surabaya are served by septic tanks or latrines mainly for the blackwater. Seepage from septic tanks soak away and latrines is very susceptible for health especially when the neighborhood used local groundwater for domestic purposes. It is regulated that soak away and latrines must be at least 10 m from groundwater sources like dug wells. This research is aimed to study the organic removal and total coliform from the tanks and latrines as it is regulated. Laboratory scale reactors are constructed of PVC type upflow reactors with 100 cm and 50 cm height to access such removal. COD, BOD, and total coliform of 100 cm height reactor is 58%, 76%, and 98%, respectively (with influent concentration of 1.720 mg COD/L, 688 mg BOD/L, and 1,700 MPN total coliform/100 mL). Depending on soil types, organic and total coliform removal is significantly reduced along the groundwater flow, especially in an undisturbed soil.

Key words: *Organic removal, Total coliform removal, Soak away, Pit latrines, and upflow reactors.*

Introduction

Septic tanks are used at large in developing countries and let alone in under-developed countries which even they may still use pit latrines. Septic tank technologies may be obsolete as demand to upgrade the sanitation into sewerage system is strongly pronounced world-wide. The existence of septic tanks, however, will last up for some time as goal 6 of SDG is still universal access for clean water and sanitation (Agustaria *et al.,* 2019). Use of septic tanks in Indonesia is even stronger as sewer coverage in urban areas of Indonesia is remain the same of about 1% in the last 20 years. Septic tanks still play an important role in Indonesia sanitation system as they are used al large with poor management system as not being desludged for more than three years as regulated through Public Works Ministry Regulation Number 04/2017; this is to exclude the practice of defecation in the open and use pit latrines. Seepage from septic tank's soak away and latrines are very dangerous (Soedjono *et al*., 2019), especially it is caused by pathogenic microorganism as total coliforms (Health Regulation Number 18, 2016). Organic materials like BOD or COD may be removed along the groundwater flow, but total coliform may stay for sometime in the water depending on the ground water flow (Muzambiq *et al.,* 2018; Hek *et al.,* 2018). Typical permeality in sandy soil (K value) like in Surabaya is 1.35×10^{-9} m/s (Mustaha, 2010). According to Indonesia Standard 2398:2017 and Health Ministry Regulation Number

892/1999, minimum distance soak away or latrine to raw water from groundwater sources is 10 meters. The standards do not mention about population or house density regarding the distance. According to the Kepmenkes: household wastewater must not pollute water bodies or groudwater and create odor. Dense population or house density in the urban area may stop the practice of using septic tanks, let alone pit latrines, as it is very potential to pollute water bodies. According to Public Works Ministry Regulation Number 04/2017, on-site sanitation system like septic tanks and latrines is called SPALD-S.

Sukolilo District as part of total 31 districts in Surabaya City, is located in East Surabaya as shown in Figure 1. The district consists of 7 sub-districts: Nginden Jangkungan, Semolowaru, Medokan Semampir, Keputih, GebangPutih, Klampis Ngasem, and Menur Pumpungan. Population in the district is 114,309 with build area of 23.66 Km^2 (BPS, 2019). Population density in the district is 4,831,3 persons/km^2 which is quite high (BPS, 2019). Not only not to have a proper SPALD-S, but there are still 496 households in the district which still practice open defecation (Ardhianto *et al*., 2014). The rest of the households convey blackwater to septic tanks or latrines while greywater is directly disposed to open ditch in front the house (Ibrahim, 2017; Natsir *et al.,* 2019). As situation is quite critical, then the objective of the research is to study disturbed soil test to remove organics in a laboratory scale. As the laboratory in ITS which is in Sokolilo District, soil sample can be easily collected around while the environment conditions for SPALD-S matchs with the vicinity as mentioned above.

Research Method

This research is to study organic and total coliform removal in disturbed soil to represent removal of those parameters in groundwater. To represent groundwater flow and soil condition in Keputih Sub-District of Sukolilo District, two reactors are constructed as shown in Figure 2.

As the flow was very sensitive due to quantity, then two PVC reactors of 100 mm diameter were constructed with an upflow system to ease the flow (as compared to down flow system). It is not necessarily required to have a down-flow or horizontal flow reactors as the pollutant to be removed is likely

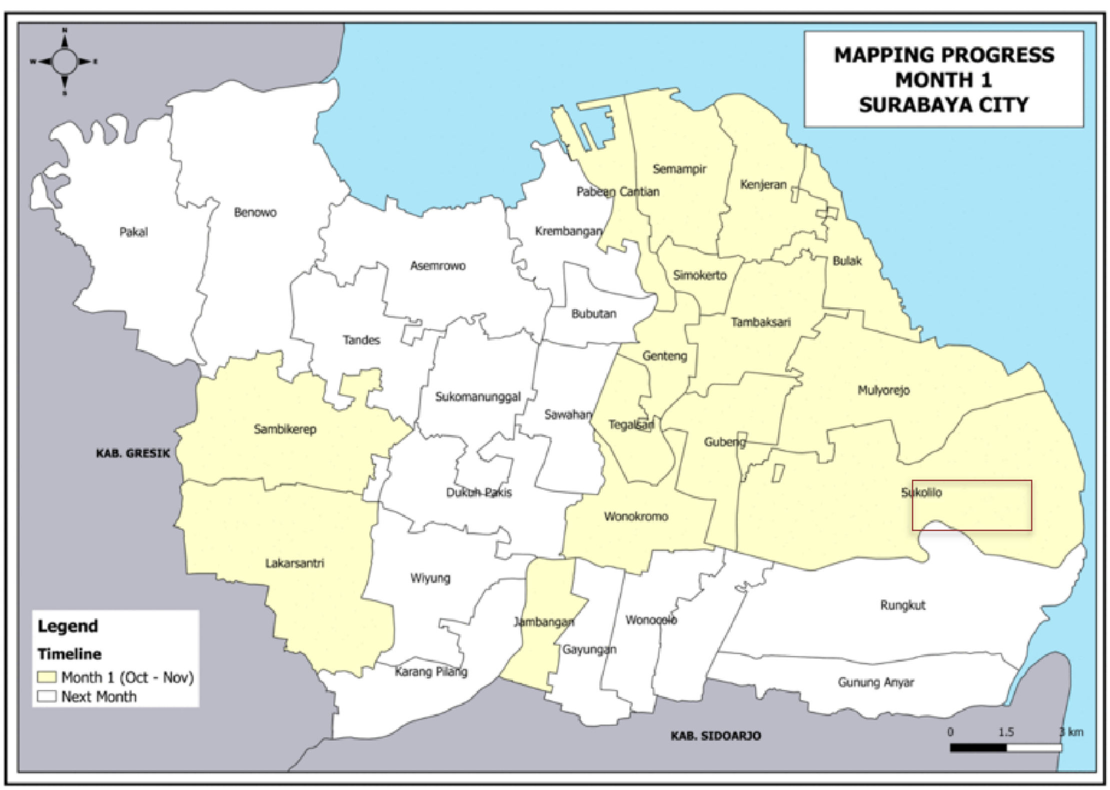

Fig. 1. Location of Sukolilo District in Surabaya City

in a dissolved solid form. Reactors flow were adjusted for 20 days to have a proper flow of 5mL/ day to adjust to soil permeability of 1,35 x 10^{-9} m/s. Soil was collected from local area at Kelurahan Keputih where ITS campus belongs. One reactor was 50 cm high while the other was doubled (100 cm high) to ease removal comparison. Wastewater sample was collected from septic tank sludge truck where it unloaded the sludge at IPLT Keputih (septic tank sludge disposal and treatment of Surabaya). Sampling was already started in the first 20 days to stabilize COD removal before the real experiment was started. Wastewater storage as shown in Figure 2 was to flow the two reactors by gravity with flow control/adjustment to represent K value of soil (Muntaha, 2010) with a flow of 5.69 mL/day for both reactors. Samplings were conducted at inlet and outlet of reactors. Parameters included BOC, COD, and total coliform according Minister of Environmental Regulation 5/2014.

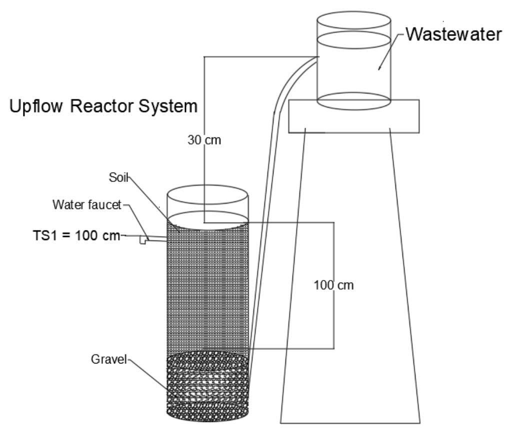

Fig. 2. Upflow reactors

Results and Discussion

Organic removals

Results of COD removal in the two reactors (reactor with 100 cm and 50 cm high and so called R100 and R50, respectively) are shown in Figure 3 and 4; while BOD removal is shown in Figure 5 and 6. The initial COD and BOD were 1,720 mg/L and 688 mg/L, respectively.

Although the height of R100 was doubled than R50, but its COD removal was not the case. Average COD removal at R100 was 58% while removal at R50 was 33%.

Average BOD removal at R100 was 76% while at R50 was 69%. Like COD removal, BOD removal at

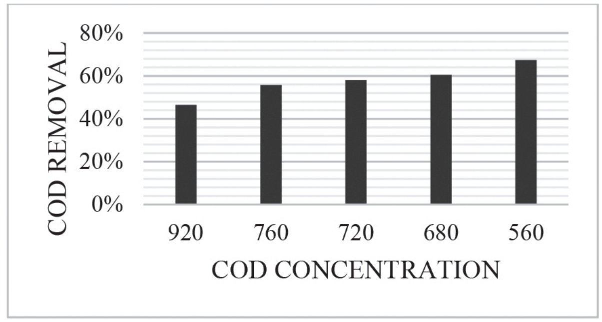

Fig. 3. COD removal in R100

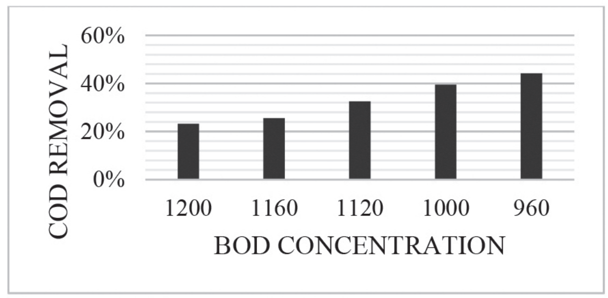

Fig. 4. COD removal in R50

R100 was not twice of R50. Soil was able to remove organic in the water when wastewater passed through it. The removal was increasing as it seems soil porosity was decreasing due to clogging over time when organic passed through it. COD and BOD removal at 100 cm distance of 58% and 76% to give concentration of 412,8 mg COD/L and 165,12 mg BOD/L was quite significant as with minimum distance 10 m, then this removal would be quite high to give COD and BOD concentration of less beyond the wastewater quality standard. According to Ningrum (2018), sand filtration with aeration system successfully reduce organic matter about 65%, however different result explained by Purwatiningrum (2018) that biofiltration only removed COD and BOD about 15% and 12%, respectively. In an undisturbed soil with different varietis of soil, the removal would be much even higher. This is to say that distance of less than 10 meters would be adequate to locate between groundwater source and septic tanks or pit latrines (Asmadi and Suharno, 2012; Ashoka and Bhat, 2012). The longer the distance for wastewater to pass through the soil, the higher is the removal of the organics and most other parameters (National Standardization Agency, 2009). COD and BOD standard was 100 mg/ and 30 mg/L, respectively (Permen LH 68/ 2016).

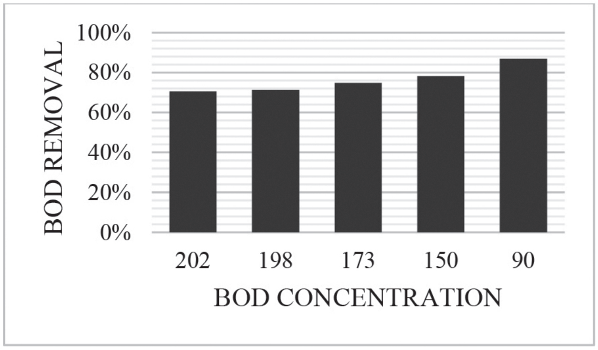

Fig. 5. BOD removal in R100

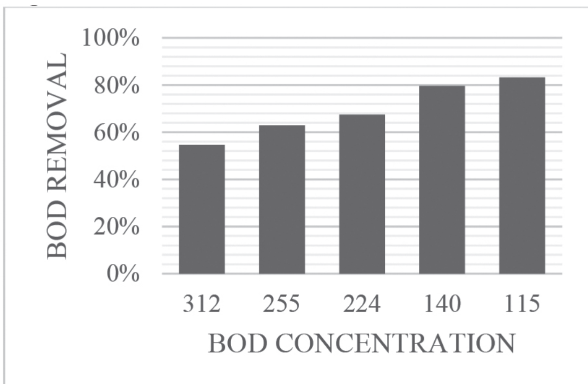

Fig. 6. BOD removal in R50

Removal of total coliform

The same condition as for organic removal, total coliform removal is shown in Figure 7. Total coliform removal at R100 and R50 is respectively 98% and 96%.

COD, BOD, and total coliform removals are increasing along the sampling periods. This is to say that the real removal on site in an undisturbed soil the removal will also increase significantly. The performance of sand filtration in removing total coliform is depend on the contact time and filtration rate. Biological process probably occurred in this reactor. Ni'matuzahroh (2020) indicated that microorganisms are found and growing in sand media. Besides, water turbidity is much reduced although it cannot be said that the water is very clear after 100 cm distance and it has no odor. This kind of water maybe still be used for washing purposes in such densely populated areas.

Conclusion

This research concludes that sewerage system is ideally implemented in densely urban housings, but the use of septic tanks and pit latrines are still at large in most of Indonesia big cities like Surabaya. Although Surabaya is mostly served by water supply (and also by SPALD-S), but the use of groundwater in the form of dug wells is still many in numbers which is susceptible from seepage from SPALD-S. Removal of organics in term of COD and BOD, and removal of total coliform from R100 is 58%, 76%, and 98%, respectively. This removal is increasing along the time of the experiments (2 months) in disturbed soil of the reactor. The removal may increase significantly on site in an undisturbed soil. This is to say that groundwater use in densely populated area for washing is still at large as soils are able to remove such pollutants significantly, as the water is also odorless.

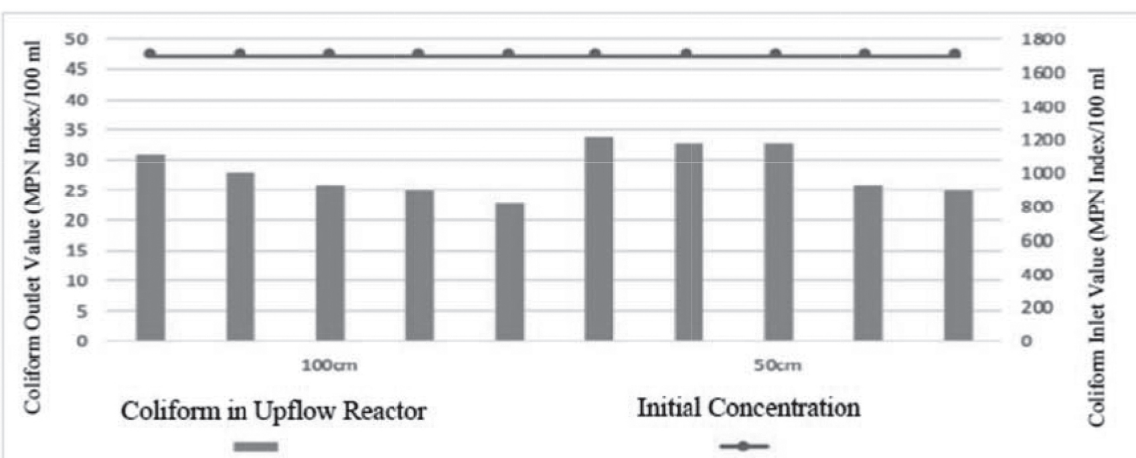

Fig. 7. Total Coliform Removal in R100 and R50

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