Development of a Simple Treatment System for Microplastic Pollution in Water Environment

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Abstract: Microplastics are small-sized and microscopic plastic materials produced by both commercial product development and the breakdown of bigger polymers. Microplastics can be hazardous to the environment and animal health as a contaminant. For the first time, scientists discovered microplastic contamination in human blood, with the microscopic particles found in over 80% of those examined. In a city like Khulna, microplastic contamination of water bodies is becoming an alarming issue day by day. Microplastics are entering directly into the human body through the food chain. This study aims to develop a simple treatment system for microplastic pollution in water environment and monitor the performance of the developed treatment system.

The FTIR analysis test proves that there is the presence of microplastics. There is a relation between the wavenumber and absorbance of a tested sample. The lighter the atoms the higher the frequency of wavenumber. This means the concentration of microplastics is much lower if the frequency is high. From the figure, three peaks in the graph were identified. The lowest wavenumber 67.96/CM was found at absorbance 474.488(%T). This test result indicates the presence of microplastics. Another two down-peaks were likely to be less susceptive.

A total of five water samples were collected from five different locations to assess the quality. Water samples from the Rupsha river bank at the Khan Jahan Ali bridge site in Lobon Chora and manually made samples were tested. Testing of the sample includes TS, TDS, TSS, Turbidity and Microscopic Examination. Then simple filtration techniques of various combinations and layers of brick chips, stone chips and mix of the materials were tested, whether the microplastics were reduced or not. The values were satisfied and prove that the rates and concentration of microplastic were significantly lower. The value showed for Brick chips, Stone chips and Mixes of 3 inch & 6-inch values were respectively TS (1390, 65, 84; 1140, 142, 109; 993, 127, 78 mg/L), TDS (200, 57, 79; 910, 98, 68; 930,74, 41 mg/L), TSS (90, 8, 5; 230, 44, 41; 63, 53, 37 mg/L), Turbidity (0.94, 1.51, 11.8; 0.88, 8.71, 9.1; 1.47, 6.2, 7.5 N.T.U). The results achieved after conducting the tests, it proves that the presence of microplastics was significantly reduced after providing 3 and 6-inch layers of brick chips, stone chips and their mixes of brick-stone chips.

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Keywords. FTIR Analysis, Microplastic pollution, Water Contamination, TDS, Turbidity.

1 Introduction

Nowadays pollution is a massive problem and issue for the world. Air pollution, water pollution, sound pollution and so many other pollutions are challenging issues for humans. The current and future world will have to face these problems. One of the major pollution is water pollution. People knowingly or unknowingly do this kind of pollution. Plastic pollution is a major problem in one of them. In the environment, plastics are usually degraded into smaller pieces. They can be degraded up to the micro level of it. These plastics are called Micro Plastic (MP). Microplastics are small plastic particles, ranging in size from less than 5 mm down to nanoscale, that are released into the environment from various sources such as industrial processes, household products, and waste disposal (Cole et al., 2011; Koelmans et al., 2016). They infiltrate natural environments through several sources, such as cosmetics, clothing, food packaging, and industrial processes, and they contaminate them.

Since the start of commercial manufacture in around 1950, mankind has become more and more reliant on plastics. Global demand has been stoked by their adaptability, stability, lightweight, and affordable production costs. The majority of plastics are used and dumped on land at first. However, it is anticipated that by 2030, the amount of microplastics in some marine compartments will have doubled. Microplastics (MPs) are a part of our daily lives in a variety of ways, including in our drinking water, table salt, clothing, washing machines, and even the air we breathe. Peeling MPs also occurs when food is heated in a polypropylene plastic container. As a result, these ingested MPs go towards our gut, where they like to thank the Environmental Engineering Laboratory technician partially collect in the digestive system and expel excreta. A little over 335 million metric tons of plastic items were produced in 2016, whereas 348 million metric tons were produced in 2017. The pervasive manmade contaminants known as microplastics (MPs) significantly pollute the aquatic environment. The slow introduction of MPs may cause several species in the marine environment to go extinct. The major health issues in humans brought on by the direct consumption of aquatic animals that contain MPs are also the fault of these plastic particles. The origin, transportation, and separation of MPs have therefore been the subject of much inquiry. What will happen to these MPs who are cut off from the water, however, is still an open issue. Because of this, we autopsied the whole phenomenon in this article to give a solution to this topic and a helpful technique for recycling these extracted MPs into economically viable items.

Microplastics can enter the environment from various sources such as personal care products, textile fibers, synthetic rubber, road markings, paint, fishing gear, and plastic waste (Geyer et al., 2017; Kershaw et al., 2016). From the perspective of Bangladesh, Microplastics are alarming issues for rivers, lakes, and in case of agriculture. In recent studies, it is seen that MPs are found in human blood and also in

the lungs. The plastic handling it isn't strictly maintained or the authority doesn't take perfect action regarding this issue. For this, the environment is facing damage.

The work which is done in this thesis helps to identify microplastics and minimize them from the water environment.

2 Methodology

2.1 Experimental procedure

The flow diagram of the whole experimental procedure is depicted in Fig. 1.

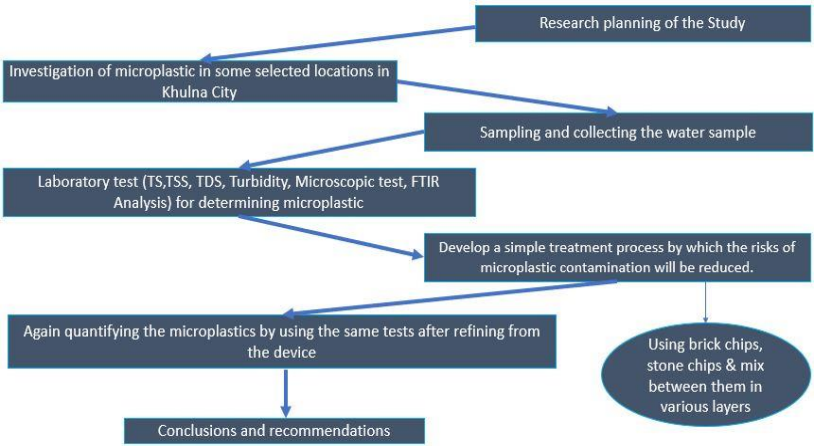


Fig. 1. Flow diagram of the experimental procedure

2.2 Study Area

Khulna is the Southern city of Bangladesh and its area is 64.78 sq km, stands on the bank of the rivers Rupsha and Bhairab. Geographically, Khulna lies 21°38' and 23°1' north latitudes and in between 89°17' and 89°32' east longitudes.

Samples were gathered from 4 sampling stations based on the distinguishing features of the locations prior to selecting the sampling sites from a well-studied reconnaissance survey. Standard protocols were used to gather samples from the ground and the surface. Samples were collected and sent to the laboratory, where they were promptly examined.

Table 1: Sample locations longitude and latitude

Location	Latitude	Longitude
1	22°82'03.7"	89°56'25.1"
2	22°76'86.1"	89°57'60.3"
3	22°78'08.6"	89°58'17.9"
4	22°79'50.8"	89°58'09.2"

2.3 Experimental Setup

A 6 inch width and 24 inch length, horizontal drain setup was built by 5m.m. depth glass plates. And it was made sure that samples can't leach from the sides of it. One end was closed with a glass plate and the other end was open.

Fig. 2. Glass made open channel drain

2.4 Preparation of Synthetic Water Using MP

To obtain the result perfectly, following procedures were followed.

Fig. 3. Different setups for testing the MP

From Fig. 3, the first photo represents the microplastics which were less than 5 mm in length. By using a scissor the samples were cut from unused plastics and made sure it was smaller than 5 mm. About 5 gm plastics were taken and then it was mixed in 1000 ml distilled water. The sample was ready for the TS, TDS, TSS, and Turbidity tests. After that Microscopic examination was done.

2.5 Preparation of Treatment System

The vertical drain was made and the description is in section 2.3. Then different materials like brick chips, stone chips, and gravels were collected. The normal size of each material was 0.5-1.3 inch. At first, all the materials were washed well with water. Then it was dried.

Fig. 4. Different materials used in test

The combination between brick chips, stone chips and also the combination of two layers were set and tested for water quality parameter. 3 inch and 6 inch layer were formed separately.

Fig. 5. Various layers of a combination of materials to retain MP

2.6 Laboratory Measurements of Microplastic Sample

The laboratory examined the Microplastic parameters of the obtained samples. Microscopic test, Turbidity, TS, TDS, TSS, and FTIR(Fourier transform infrared) of some samples were among the parameters. Standard procedures were used to test all of the parameters. TDS was measured by keeping the water sample in the oven for 24 hours at 105°C. After that, each test Microscopic test was done. The MP parameters were compared with their respective standard value.

Fig. 6. TDS, TS, TSS test photos

The following figure depicts the experiment while taking the values of TS, TDS and TSS tests.

2.7 Data Analysis for Samples of MP

The study assessed the water quality using various water quality measures such as Turbidity and TDS classes. Different combinations of brick chips, gravels, and stone

chips were used at different layers. For reducing the MP from its water sample. Various indicators such as TSS, TDS, and Microscopic examination were determined to assess the amount of MP from sample water. In addition, the acceptability of each sample water MP parameter was determined by comparing it to its appropriate standard value.

3 Illustrations

3.1 Figures and Graphs

Samples were collected from sampling sites. Two samples were tested. The result of the graph is shown below. Which are location 1 and location 2.

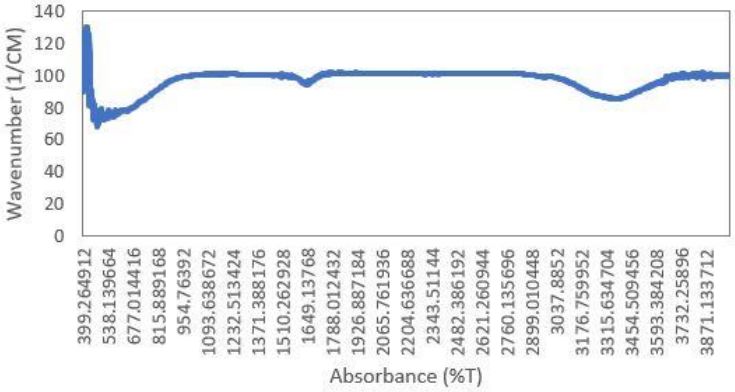


Fig. 7. FTIR Analysis graph of testing location 1

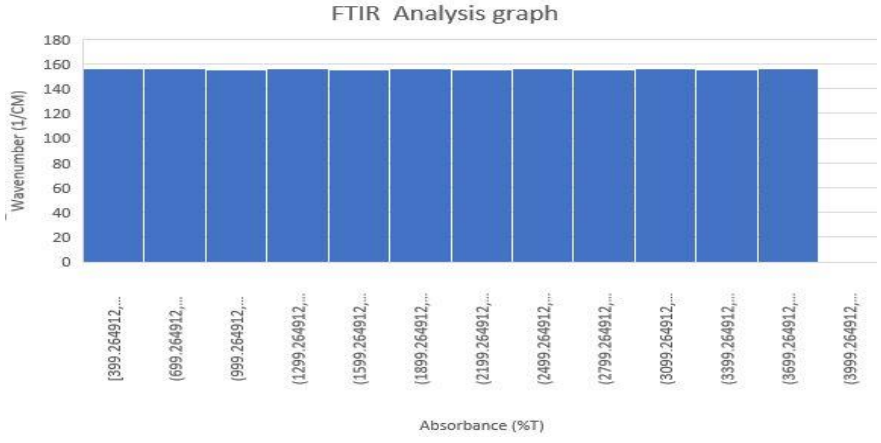
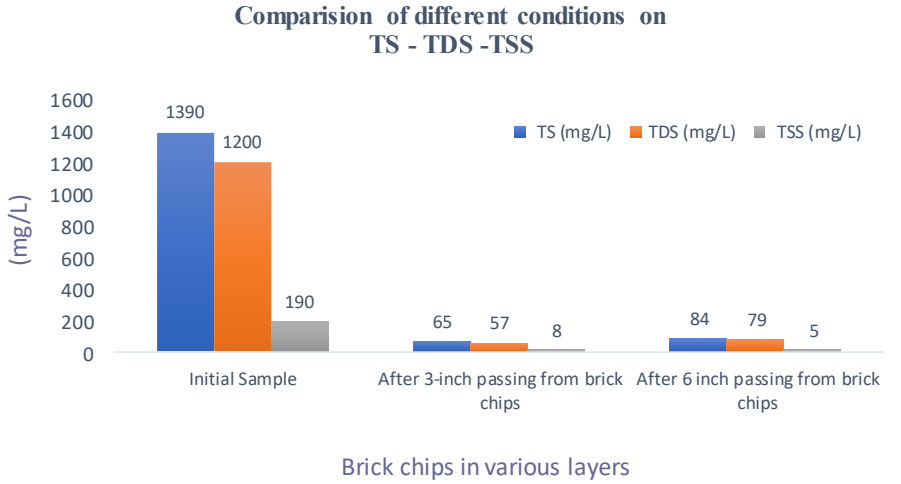


Fig. 8: FTIR Analysis histogram graph of sampling location 2

3.2 Microplastic Concentration Test Results

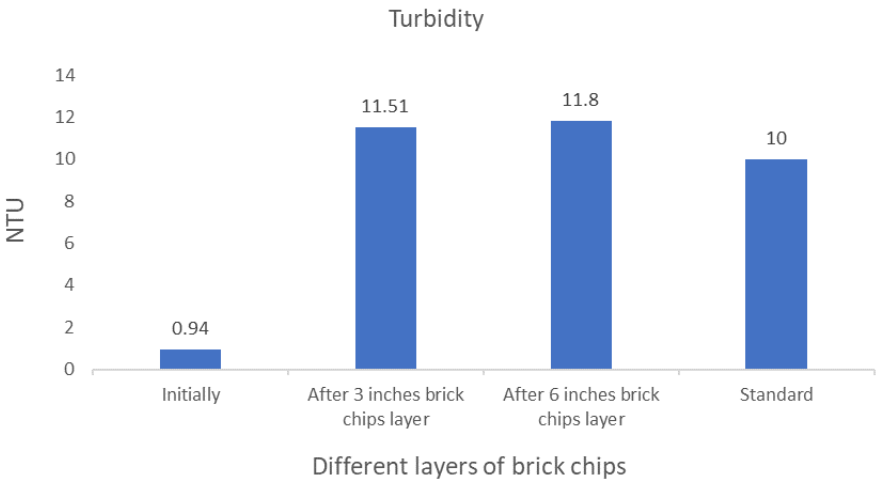
As the collected sample contains so little amount of microplastics, the preparation of synthetic water in microplastics was done. The procedure is described in section 2.4. Then after and before filtration, the tests were conducted in different conditions. The results are described below.

By Providing a Layer of Brick Chips. At first, brick chips layers were provided. The graph regarding the values represents different values of TS, TDS and TSS.



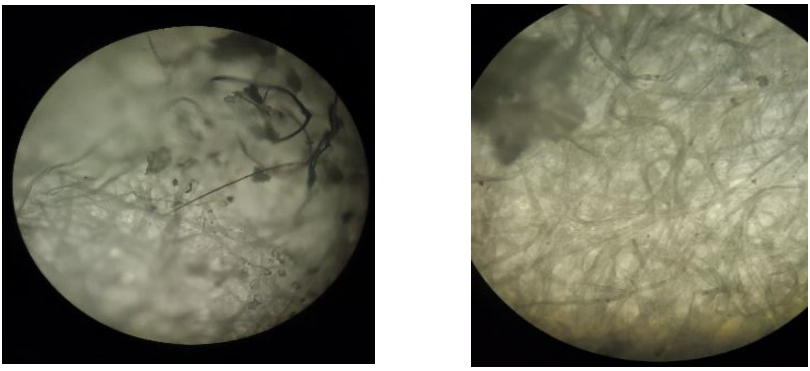
Initially, TS value was 1390 mg/L. The same MP sample was pass through the 3 inches layers of brick chips and the value became significantly lower. It was 65 mg/L after passing from the filter layer. And 84 mg/L after passing from 6 inches layers of brick chips. The TDS and TSS values were significantly reduced. The values of TDS initially and after passing from 3 and 6 inches layers of brick chips are 1200 mg/L, 57 mg/L and 79 mg/L respectively. TSS values are 190 mg/L,8 mg/L and 5 mg/L respectively.

Turbidity .



Initially turbidity of sample water was so low which is 0.94 NTU. After passing from 3 and 6 inches of brick chips layers the turbidity value became much higher. Which are 11.51 NTU for 3 inches and 11.8 NTU for 6 inches. It indicates that there is less amount of microplastics present after passing through the filters.

Microscopic view .



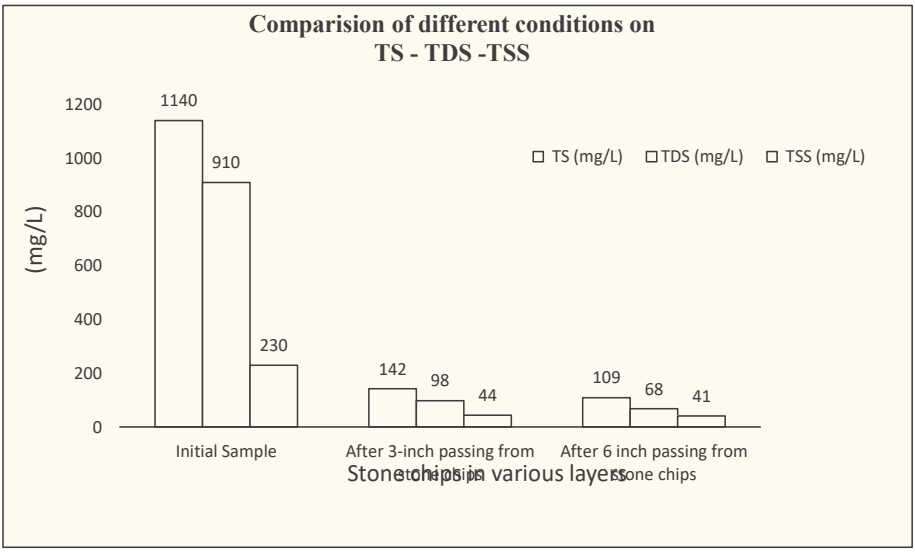
Initial Sample

After passing from 6 inches layers of brick chips

Fig. 9: Microscopic view of MP Initial and after filtering (Brick Chips) the sample

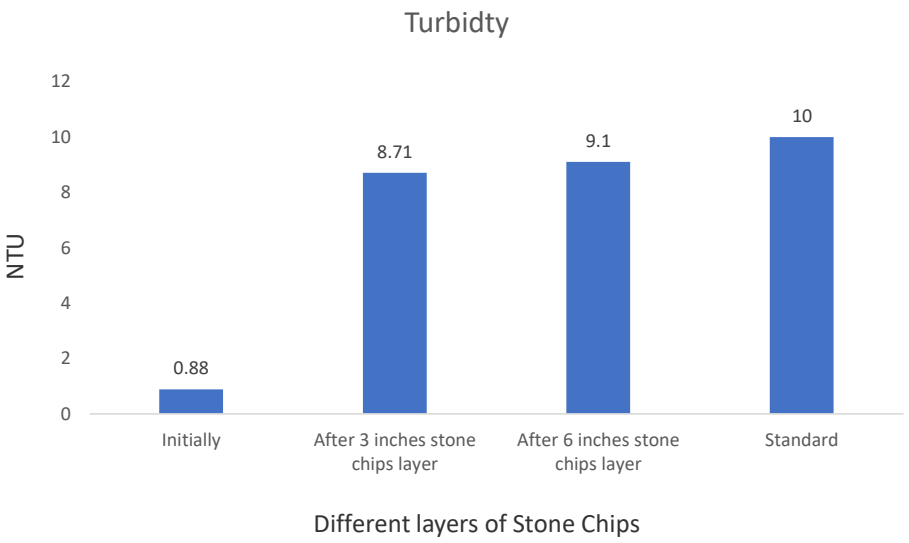
3.2.1 By providing Layer of Stone Chips

After the conducting the tests on the basis of brick chips, same procedures were followed in terms of stone chips.



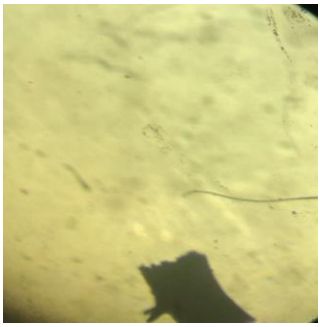
Initially, TS value was 1140 mg/L. The same MP sample was pass through the 3 inches layers of stone chips and the value became significantly lower. It was 98 mg/L after passing from the filter layer. And 109 mg/L after passing from 6 inches layers of brick chips. The TDS and TSS values were significantly reduced. The values of TDS initially and after passing from 3 and 6 inches layers of brick chips are 910 mg/L, 98 mg/L and 68 mg/L respectively. TSS values are 230 mg/L, 44 mg/L and 41 mg/L respectively.

Turbidity.

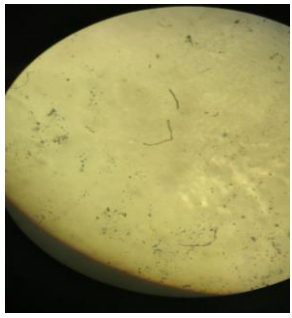


Initially turbidity of sample water was so low which is 0.88 NTU. After passing from 3 and 6 inches of stone chips layers the turbidity value became much higher. Which are 8.71 NTU for 3 inches and 9.1 NTU for 6 inches. It indicates that there is less amount of microplastics present after passing through the filters.

Microscopic view.



Initial Sample

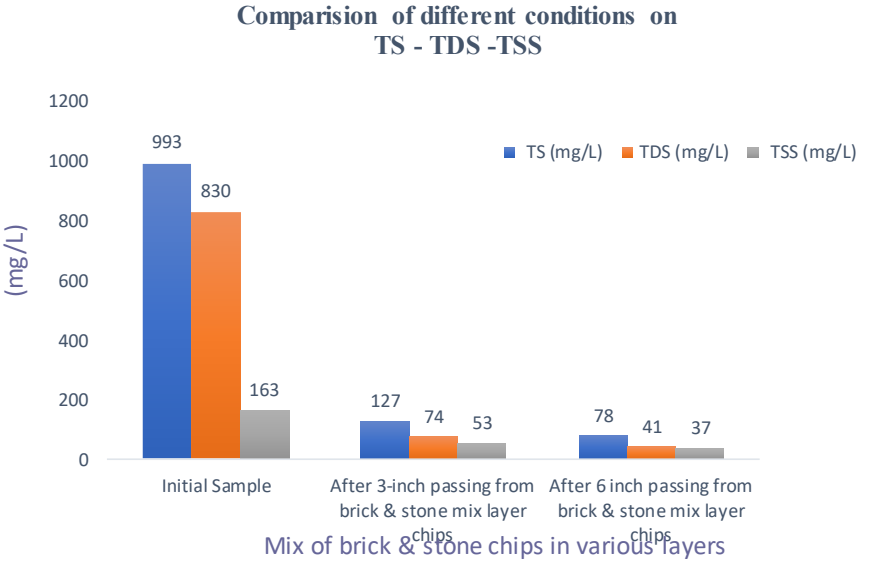


After passing from 6 inches layers of stone chips

Fig. 10. Microscopic view of MP Initial and after filtering(Stone Chips) the sample

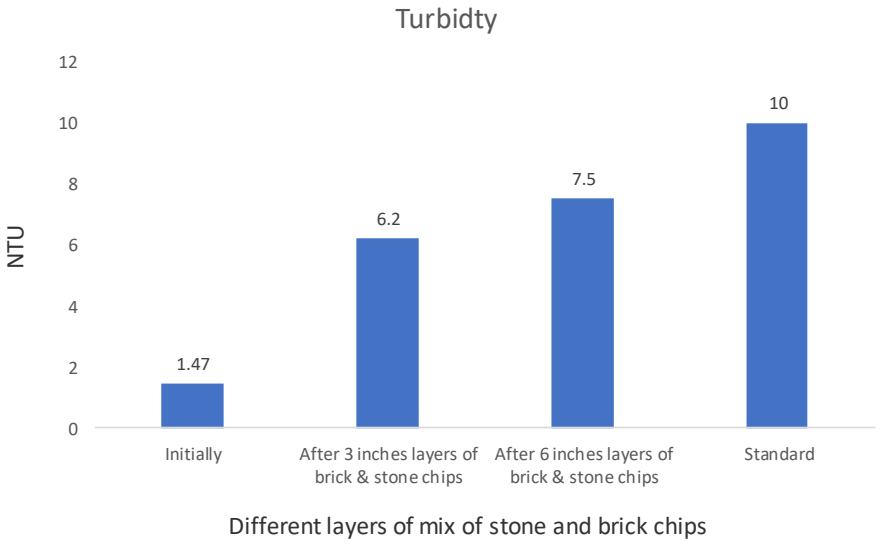
In Fig. 10, the microscopic examination photo is given before and after the filtering of the sample. From the microscopic examination photo, it is observed that there are black dot rounded circles and sticky lines which are MP. But in the second microscopic examination photo, the MP was reduced.

By providing a Mix Layer of Brick & Stone Chips. Finally, the mixed layer of brick and stone chips were taken under condition and the same procedures.



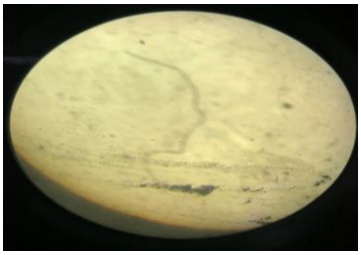
Initially, TS value was 993 mg/L. The same MP sample was pass through the 3 inches layers of brick & stone chips and the value became significantly lower. It was 127 mg/L after passing from the filter layer. And 78 mg/L after passing from 6 inches layers between the two materials. The TDS and TSS values were significantly reduced. The values of TDS initially and after passing from 3 and 6 inches layers of brick chips are 830 mg/L, 127 mg/L and 78 mg/L respectively. TSS values are 163 mg/L, 53 mg/L and 37 mg/L respectively.

Turbidity :

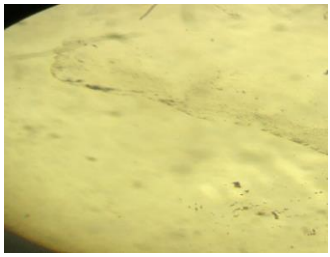


Initially turbidity of the sample water was so low which is 1.47 NTU. After passing from 3 and 6-inch layers of brick & and stone chips, the turbidity value became much higher. Which are 6.2 NTU for 3 inches and 7.5 NTU for 6 inches. It indicates that there is less amount of microplastics present after passing through the filters.

Microscopic view.



Initial Sample



After passing from 6 inches layers of brick & stone chips

Fig. 11. Microscopic view of MP Initial and after filtering (Brick & Stone Chips) the sample

In Fig. 11, the microscopic examination photo is given before and after the filtering of the sample. From the microscopic examination photo, many black dot rounded circles are MP. However, in the second microscopic examination photo, the MP was reduced significantly.

4 Conclusions

The first objective of this study was to identify the microplastics. The FTIR analysis test proved that the samples contained microplastics. Though the amount was so less. The sharp dark sticky lines are suspected as microplastics. The relation between the wavenumber and absorbance of a tested sample has already been presented above. The lighter the atoms the higher the frequency of wavenumber. This means the concentration of microplastics is much lower if the frequency is high. Three significant peaks in the graph were identified. The lowest wavenumber 67.96/CM was found at absorbance 474.488 %T. This test result indicates the presence of microplastics. Another two down-peaks were likely to be less susceptive. The second objective of this study was to minimize the microplastic in the water environment. Laboratory analysis for the following samples obtained value for filtering from Brick chips, Stone chips and it's mix between these materials by providing 3-inch and 6-inch depth. The value showed for Brick chips, Stone chips and Mixes of 3 & 6-inch values are respectively TS (1390, 65, 84, 1140, 142, 109, 993, 127, 78 mg/L), TDS (200, 57, 79, 910, 98, 68, 930,74, 41 mg/L), TSS (90, 8, 5, 230, 44, 41, 63, 53, 37 mg/L), Turbidity (0.94, 1.51, 11.8, 0.88, 8.71, 9.1, 1.47, 6.2, 7.5 N.T.U). For this study, various water sample conditions were checked. Test results indicated that microplastic concentration and rates both were significantly reduced by using the simple filter technique. Because the values of TDS, TS, and TSS of each value were satisfied. Also, Turbidity values indicated the same. And at last Microscopic examination test results are well to prove that MP was reduced.

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References

1. Barcelo, D., & Pico, Y. (2020). “Case Studies of Macro- and Microplastics Pollution in Coastal Waters and Rivers: Is There a Solution With New Removal Technologies and Policy Actions?” Frontiers in Marine Science, 7, 927.
2. Borerro, J. C., Carson, H. S., Eriksen, M., Lebreton, L. C. M., Moore, C. J., Reisser, J., & Thiel, M. (2014). “Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. PLoS ONE, 9(12), e111913.”https://doi.org/10.1371/journal.pone.0111913
3. Chen, G. (2019). “Mini-review of microplastics in the atmosphere and their risks to humans.” Science of the Total Environment, 651, 3253-3259.
4. Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: A review. Marine Pollution Bulletin, 62(12), 2588-2597.doi:10.1016/j.marpolbul.2011.09.025
5. Dey, T. K., Jamal, M., & Uddin, M. E. (2021). “Detection and removal of microplastics in wastewater: evolution and impact." Environmental Science and Pollution Research, 28(1), 747-765.
6. Koch, M., Lenz, P., & Metz, T. (2016). Quantification of microplastics: Which parameters are essential for a reliable inter-study comparison? Environmental Pollution, 215, 467-478.