__Original Research Article__

Application of Recycled Plastic Media to Enhance Processes of a Waste Water Treatment Plant

ABSTRACT

Increased environmental awareness and treating waste water streams from municipalities, agricultural and industrial producers in an environmentally sound way makes it necessary to look at processes inspired by nature.

The presented research focus performed at the Cleanwater Educational Research Facility, located at the waste water treatment plant of the New York Village of Minoa was to investigate the use and application of recycled plastic materials as future growth media for different waste water treatment processes.

Six recycled plastic materials; Polyethylen-terephthalat, Polyethylene high density, Polyvinyl chloride, Polyethylene low density, Polypropylene, and Polystyrole were used for the growth media experiments at the waste water treatment plants distributer box, feed box, primary clarifier, trickling filters, sequential batch reactor, anaerobic fermenter, and chlorination vessels.

Testing was conducted during a 5-month period, measuring the test specimens for their biomass growth at a 3-week time interval that allows bacteria to generate a biomass film on the test specimen.

Biomass growth was observed on all types of plastic material at the testing locations. Results show that each process at a wastewater treatment plant prefers different recycled plastic material.

The preferred recycled plastic growth media was Polyethylene high density for primary clarifier applications. Recycled Polypropylene plastic material was preferred for applications in distributor boxes, primary clarifier, and sequential batch reactor. Recycled Polyvinyl chloride plastic material was preferred as growth material in trickling filter, anaerobic fermenter and chlorination applications. Recycled Polyethylene low density plastic material was preferred for Trickling filter and secondary clarifier applications. It is suggested that future research using recycled plastic material as growth media for biological waste water treatment processes should focus on these recycled plastic types.

Keywords: Bioremediation, chlorination, contaminants, constructed wetland, plastic media, sewage, sequential batch Reactor, subsurface constructed wetland, wastewater, recycling, trickling filter

1. INTRODUCTION

The treatment of effluent from municipal, agricultural and industrial entities that is discharged into rivers, streams, wetlands and natural water systems is important in order to reduce the reliance that nature will clean the discharged Waste Water (WW) [1].

The following research is and continuation of previously WW research projects that investigated algae growth on a Trickling Filter (TF) for the enhancement of the water treatment capability of a trickling filter as described by Doelle & Watkins [2] in their research,

which found that over 70% of the phosphorus entering the trickling filter can be removed by the algae layer, and therefore has a positive effect on water quality.
Further research carried out by Doelle and Watkins [3] investigated if algae growth on the TF is dependent on a particular carrier medium. Materials such as wood chips, larger blocks as well as cardboard, Styrofoam chips and plastic bags were included in the test series showing that Styrofoam peanuts had the highest growth rate with 7.27 g/day followed by plastic bags with 6.19 g/day, softwood wood blocks with 4.26 g/day and sugar maple hardwood wood chips with 2.27 g/day, and cardboard with 0.84 g/day.
Recent research by Dölle investigated the use and application of plastic materials as growth media for an application in Subterranean Flow Constructed Wetlands (STFCW) with the result that all recycled plastic materials showed biomass growth at all the measuring points, with PET as the most preferred growth medium for all measuring points followed by PE-LD, PS and PE-HD as well as PVC for certain locations [1].
In the past growth media such as gravel, rock, slag and wood were used for example in TF applications. These materials were replaced with materials such as Polyvinyl Chloride (PVC) and Polypropylene (PP), because engineered growth media provide a much higher surface area as wood and rock growth media and allow a higher throughput and increased WW treatment capabilities [4,5,6,7,8].
Optimizing natural processes inspired by natural biological processes such as the TF past and current growth media and implementing them in technical solutions is also called biomimicry, which can lead to a more environmentally friendly and sustainable process [1].
Using recycled plastic materials for biological growth applications falls under the field of biomimicry. If successful it opens the field of WW engineering to implement recycled materials on a large scale, allowing recycled plastic material for applications in WW treatment.
The presented research focuses on the application of recycled plastic materials in different applications of the WW treatment process to determine its application and use. The research was performed at the Minoa WWTP, Clean Water Educational Research Facility CERF under actual STFCW working condition using clarified WW.

2. MATERIAL AND METHODS

The material and methods section describes the materials, system, experimental setup, and the exact procedures and standards necessary to carry out the individual experiments.

2.1 Selection of Plastics.

Recycled plastic material as listed by Dölle in Table , gives an overview of the existing recycling number system used in the USA and Europe. Every item that is made from plastic materials is always marked with a number that indicates exactly what plastic it is made of for recycling and reuse of the plastic material [1].
For the presented research the following six types of plastic PET, PE-HD, PVC, PE-LD, PP, and PS, shown in Table 1, were used in the experiments and tested for their suitability as a growth medium in various locations of the WWTP.

T**able 1: Recycling-Number Code in the USA and Europe [1]**

Recycling-Number Code in USA and Europe			
Symbol	**Name**	**Symbol**	**Name**
01 PET	Polyethylene-terephthalat	04 PE-LD	Polyethylene Low Density

02 PE-HD	Polyethylene High Density	05 PP	Polypropylene
03 PVC	Polyvinylchloride	06 PS	Polystyrol

2.2 Procurement of Materials

As in the first study by Doelle [1], six different plastic types (PE-HD, PE-LD, PP, PS, PET and PVC) were used for this research. The plastic material for the research was obtained from a nearby recycling site, which collects and processes commercially household waste in the larger Syracuse area.

2.2 Experimental Site

At the Minoa WWTF shown in Figure 1 as a process sketch, approximately 1.8 million l/d of municipal WW enter the WWTF for treatment through an influent structure at a temperature of approximately 15°C [4] in which a prescreening process removes large impurities via a gravel trap and rake. The removed material is dried disposed of at a landfill [4,1]

The prescreened sewage leaving the influent structure is split in half. A Sequential Batch Reactor (SBR) receives one half of the prescreened liquid sewage volume (900,000 liters per day). The SBR consists of two alternating parallel tanks that are operated at an alternating 4-hour aeration and settling cycle [4] during which the biological colony in this tank consumes the organic fraction of the wastewater, reducing the Biochemical Oxygen Demand (BOD) and Ammonia (NH_3). After the aeration and settling period, the treated WW is removed with a mechanical decanter and passes a chlorination treatment before it is discharged into a stream. The produced biosolids from bacterial growth, also called primary sludge of the SBR are collected in a separate tank adjunct to the treatment tanks [4].

The other half of the prescreened sewage (900,000 liters per day) is pumped to a primary clarifier settling tank where about 30% of the organic substances are removed from the prescreened sewage by sedimentation as primary sludge [4].

Half of the clarified water, approximately 450,000 liters per day, is directed to the STFCW that currently consists of 3 cells. The first 2 cells operate on a fill drain cycle, while Cell 3 operates as a through flow cell receiving WW from Cell 1 or Cell 2. All three cells are planted half with grass and the other half with Phragmites. After STFCW treatment the 450,000 liters per day effluent is redirected into the influent box of the Trickling Filter Feed Tank where it mixes with the other 450,000 liters per day from the primary clarifier. Two Trickling Filter receive the combined flow of 9000,000 liters per day for secondary treatment [4].

Trickling filters are in general large tanks that contain growth media [5]. In the past rock, slag and wood was a common growth media that provided a lower surface area and void volume, limiting the hydraulic flow rate of the trickling filter and therefore require more costly and larger systems for the WWPT. Today, trickling filters have been upgraded with growth media materials such as Polyvinyl Chloride (PVC), Polypropylene (PP) with an approximately 2 t o4 times larger surface area of approximately 90 to 226 m^2/m^3 compared to the rock, slack and wood material used I the past [6,7].

Organic components that leave the Trickling Filter with the treated WW are then settled in the Secondary Clarifiers adjunct to each Trickling Filter and removed as primary sludge.

Primary Sludge removed from the PC, SC and SBR is pumped into an Aeration Tank into which compressed air is supplied. The Aeration tank serves at the same time as a holding tank. During the holding time bacteria break down the pollutants further till the sludge is dewatered with a belt press. The resulting solids are dried in a drying field prior to disposal at a landfill or used for composting. The removed press water is discharged back into the WWTP influent structure.

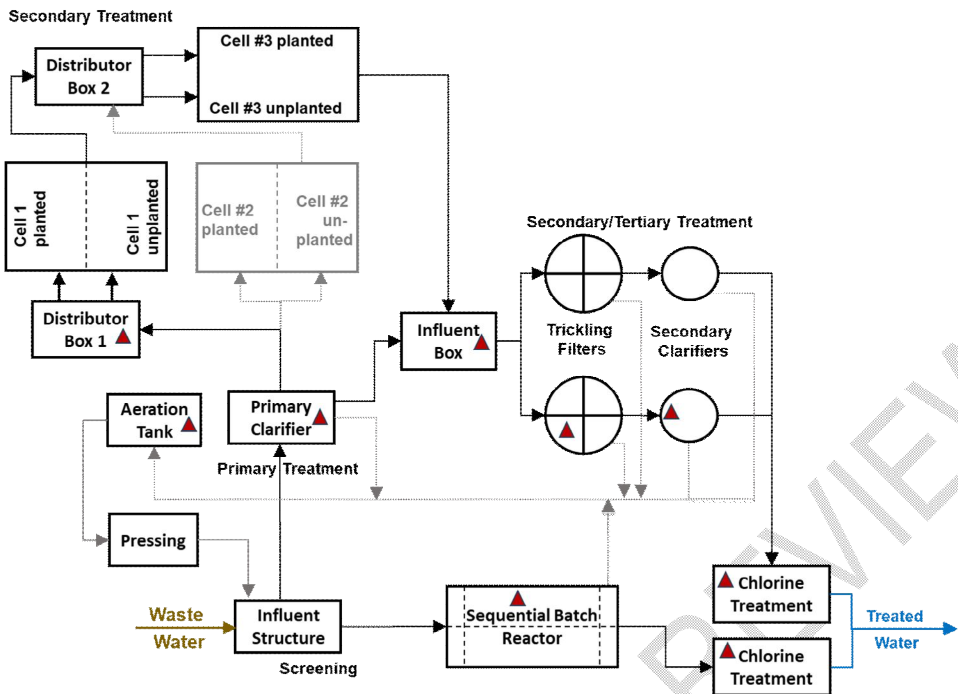

Figure 1 Waste Water Treatment Plant Process Sketch [9]

2.2. Test Location

For the biomass growth test at the WWTP the following sample locations were identified, as shown in Figure 1: a) Primary Clarifier, b) Distributor Box STFCW, c) Trickling Filter Influent Box d) Trickling Filter, e) Secondary Clarifier, f) SBR, g) Anaerobic Fermenter, h) SBR Chlorination, i) Secondary Clarifier Chlorination. In each of the sample locations three biomass growth test specimen holders were inserted for testing the biomass growth.

2.3 Construction of the Test Specimens

For testing the bacterial biomass growth with a triplicate test arrangement at the nine different test locations of the WWTP as shown in Figure 1. Twenty-seven different test arrangements with six test specimens (PE-HD, PE-LD, PP, PS, PET and PVC) each needed to be built. Each biomass growth specimen size was 1.5 cm by 1.5 cm.

In the first step the collected plastic materials were washed first thoroughly to remove any dirt or impurities that may be present so that they do not affect or even distort the measurements later. In a second step the required size of 1.5 cm by 1.5 cm is now drawn on the cleaned plastic types with a ruler and highlighter and then cut out by hand using a scissor. The fourth step consists of weighing and recording the individual test specimens, followed by assembling them on a 3 ft long bronze wire, arranged with approximately 1.5 cm long distance holders in between as shown in Figure 5a.

2.4 Duration of Tests

Testing was conducted starting October 1st with measuring the test specimens for their biomass growth using a 3-week time interval, allowing the bacteria to grow on the test specimen and spread or grow on the respective carrier materials. The last measurement was taken in the 2nd week of February.

2.5 Measurement Procedure

Every 3 weeks, starting in October, the test specimens from the nine sample locations of the WWTP locations were examined as shown in Figure 2. First, the test specimens, Figure 2a were removed from the sample location and brought to the testing laboratory at the WWTP. In a second step the test specimens were hung on a drying rack for 2 hours shown in Figure 2b. After drying the test specimens were placed on a pre weight measuring device containing 3 pins for supporting the growth media specimen and not disrupting or damaging the grown biomass (Figure 2d). In step four the biomass growth on the specimen was recorded, using a analytical laboratory balance with a 0.0001 g readability (Figure 2c) and placed back on the supporting device shown in figure 2d. Step five concluded the test specimen evaluation by assembling the specimen holder and placing the specimens back in the respective sample location.

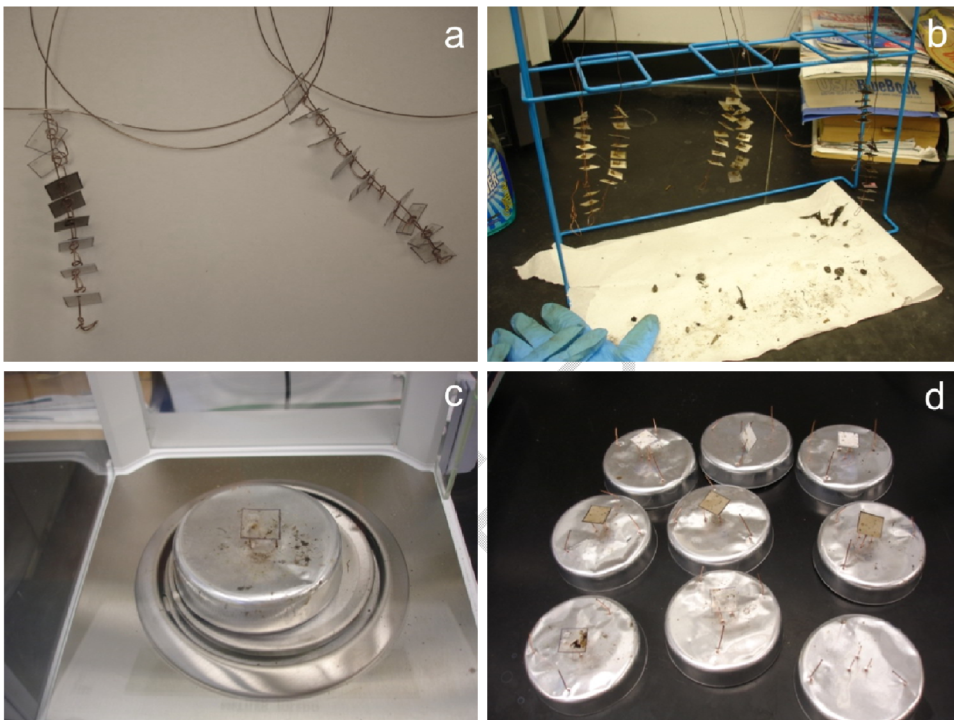

Fig. 2: Test Specimen Examination, a) sample holder, b) drying of samples, c) weighting of samples, d) storage of samples.

3. RESULTS

The following section describes the results, displayed in Figures 3 to 13 from the biomass growth study conducted between October and January using six different plastic types (PE-HD, PE-LD, PP, PS, PET and PVC) to investigate biomass growth at the WWTPs two WW treatment process trains including SBR and chlorination of the first treatment train and primary clarifiers, trickling filters and secondary clarifiers including chlorination in the second treatment train of the WW treatment.
The presented graphs show the accumulation of biomass after each 3-week measurement.
The biomass increases for all test sample locations in the WWTP show a steady mass increase for the test time from October to Mid-February. Some samples show a noticeable decline in January due to a seasonable temperature drop occurring in January associated with snowfall and frost, that cooled the WW in the open tanks below the average

temperature of 15°C [10]. Consequently, the biomass growth was negatively affected. Bacteria adopt in the system always to environmental influences. In cold temperatures, bacteria are not as active and growth slows down, subsequently the biomass built up on the carrier materials is decreased. In February the weather conditions changed again, and temperatures rose above 0°C. This allowed the bacteria to become more active again, which resulted in increased biomass growth.

3.1 Primary Clarifier

The Primary Classifier (PC) is divided into two equal sized Tank Sections (TS) 1 and 2. The growth media has been placed in both sections. Figure 3 and Figure 4 show the biofilm growth for the individual plastic materials. Both PC TS 1 & 2 receive the same WW, results of the biomass growth differ, and different plastic material are preferred in the individual TS. However, both TS show that PP is one of the preferred growth media in both tanks showing a combined growth rate of 0.1175 g for TS 1 and 0.1607 g for TS 2. The difference in growth rate of the individual test specimens can be explained with the location of the test specimens which left TS1 in a less preferred spot in the tank (dead spot) that did not receive enough fresh WW with enough nutritious content.

The total biomass growth for the PC tank section 1 was measured at 0.1267 g for PET, 0.1419 g for PE-HD, 0.1021 g for PVC, 0.1104 g for PE-LD, 0.1175 g for PP and 0.0997 g for PS during the evaluation period indicating that PE-HD, PET and PP materials are preferred as biomass growth media.

The total biomass growth for the PC tank section 2 was measured at 0.0867 g for PET, 0.1200 g for PE-HD, 0.0887 g for PVC, 0.1277 g for PE-LD, 0.1607 g for PP and 0.0891 g for PS during the evaluation period indicating that PP, PE-LD and PE-HD materials are preferred as biomass growth media.

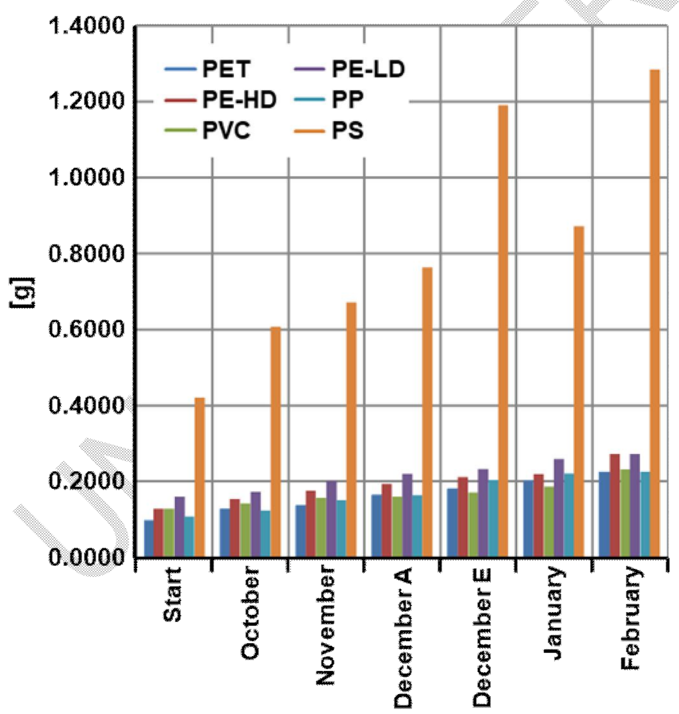

Fig. 3: Primary Clarifier Section 1

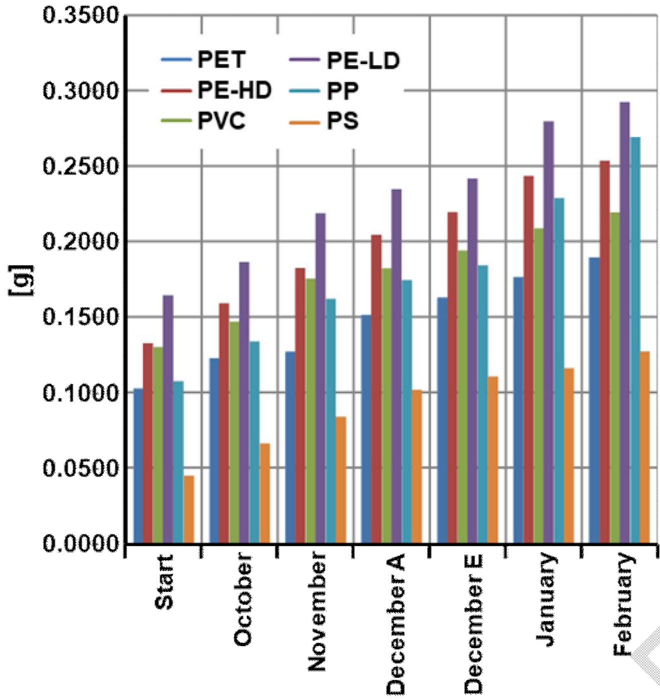

Fig. 4: Primary Clarifier Section 2

3.2 Distributor Box

The biomass growth samples placed in the distributor box of the STFCW that receives the effluent from the PC is not affected by the temperature fluctuations, as can be seen in Figure 5. This is because the distributor box is not directly connected to the outside environment, located partially underground, and the WW was not exposed to the outside environment for a long time. As a result, there is a continuous and significant biomass growth on almost all samples observed.

The total biomass growth for the Distributer box of the STFCW was measured at 0.1382 g for PET, 0.3034 g for PE-HD, 0.2028 g for PVC, 0.1928 g for PE-LD, 0.3093 g for PP and 0.1878 g for PS during the evaluation period indicating that PP, PE-HD and PVC materials are preferred as biomass growth media

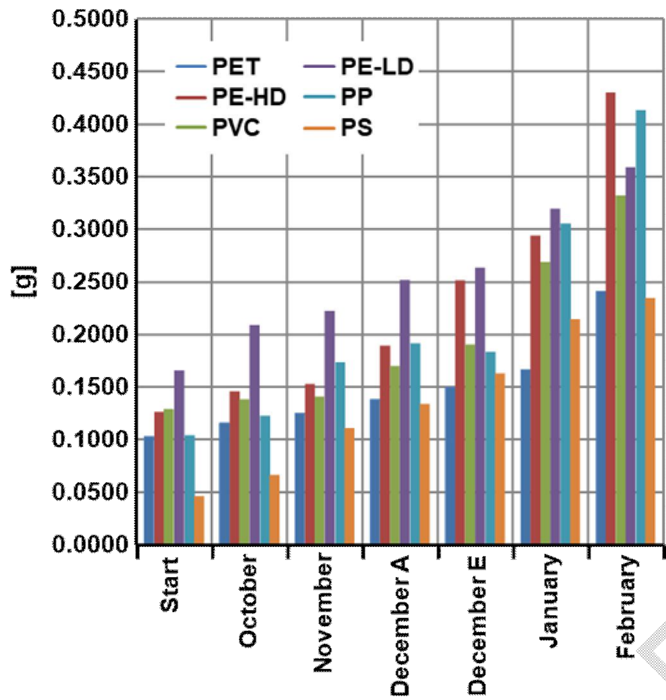

Fig. 5: Distributor Box Subterranean Flow Constructed Wetlands

3.3 Trickling Filter Feed Tank

The biomass growth samples placed in the TF Feed Tank that receives the effluent from the PC as well as the effluent of the STFCW is not affected by the temperature fluctuations due to its large and closed tank size, which is not exposed to the outside environment, as it can be seen in Figure 6. As a result, there is modest and continuous biomass growth on almost all samples observed.

The total biomass growth for the TF feed tank was measured at 0.0880 g for PET, 0.272 g for PE-HD, 0.3059 g for PVC, 0.1775 g for PE-LD, 0.2048 g for PP and 0.1440 g for PS during the evaluation period indicating that PVC, PE-HD and PP materials are preferred as biomass growth media

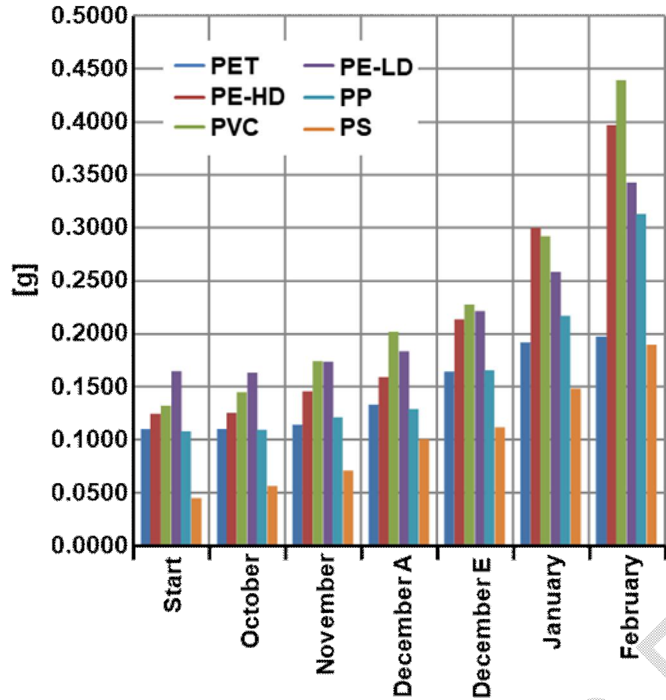

Fig. 6: Trickling Filter Feed Tank

3.4 Trickling Filter

The TF is the primary treatment process in the second WW treatment line, removing the remaining contamination through bacteria that grow on the growth medium. In addition to regular TF processes the Minoa TF contains a specific algae layer distinct to the summer and winter month on top of the media that removes phosphorous contained in the WW [3].

The TF shows a significant growth of biomass on all plastic specimens during the testing period. However, the TF is impacted by weather changes such as temperatures below 0°C fluctuations, rainfall, and rain as can be seen in Figure 7, especially during the month of December and January. This is because the pre-treated WW is sprayed with a distributor arm onto the top of the TF and is directly exposed to the environment, allowing it to cool down. As a result, biomass growth is lower on almost all samples observed.

The total biomass growth for the TF was measured at 0.1842 g for PET, 0.2084 g for PE-HD, 0.5249 g for PVC, 1.1191 g for PE-LD, 0.4363 g for PP and 0.8631 g for PS during the evaluation period indicating that PE-LD, PS, and PVC materials are preferred as biomass growth media

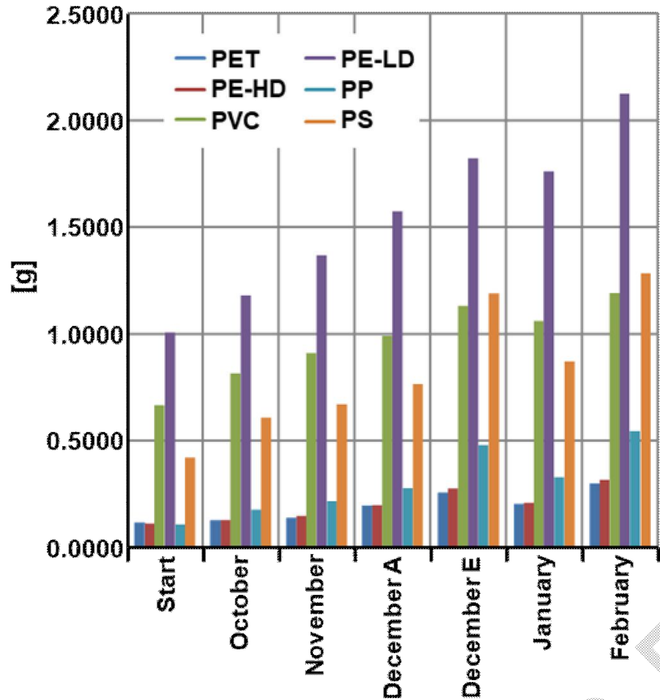

Fig. 7: Trickling Filter

3.5 Secondary Clarifier

The SC serves as the last cleaning stage before the treated WW is released into the environment, by settling out larger impurities and biomass that is contained in the treated WW. Each of the two PC receive approximately 450,000 liters per day. The PC is not affected by temperature changes and significant weather events such as temperatures below 0°C, rain and snow fall due to the fact that is buried in the ground and only the surface area is exposed to the environment as shown in Figure 8. Biomass growth on the test specimens is rather low, because most of the nutrients have been removed from the WW by the previous processes.

The total biomass growth for the SC, as shown in Figure 8, was measured at 0.0779 g for PET, 0.0531 g for PE-HD, 0.0472 g for PVC, 0.0794 g for PE-LD, 0.0571 g for PP and 0.0451 g for PS during the evaluation period indicating that PE-LD, PET, and PP materials are preferred as biomass growth media

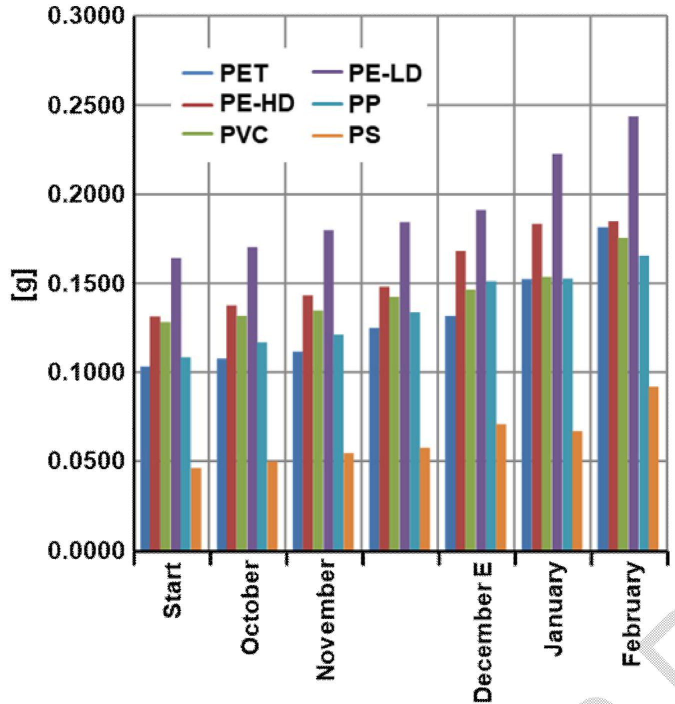

Fig. 8: Secondary Clarifier

3.6 Sequential Batch Reactor

The SBR serves as a primary treatment process in the WWTP, treating approximately 900,000 liters per day in an aeration and settling cycle, followed by decanting the treated WW. The WW in the SBR is mixed with injecting compressed air to mix the suspension and to provide the necessary oxygen for the bacteria to grow to remediate the WW. Due to the large Volume of the SBR, it is not affected by temperature changes and significant weather events such as temperatures below 0°C and snow fall. However, biomass growth on the test specimens is affected by high mixing rate and shear forces produced by the injected air during the aeration and mixing cycle, preventing the accumulation and biomass growth on the test specimens.

The total biomass growth for the SBR, as shown in Figure 9, was measured at 0.0094 g for PET, 0.0161 g for PE-HD, 0.0087 g for PVC, 0.0235 g for PE-LD, 0.0283 g for PP and 0.0110 g for PS during the evaluation period indicating that PP, PE-LD and PE-HD materials are preferred as biomass growth media

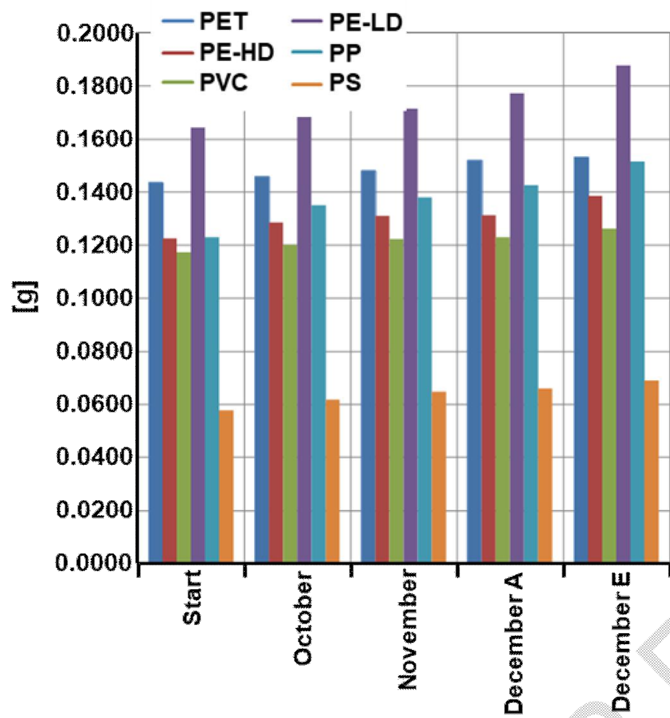

Fig. 9: Sequential Batch Reactor

3.7 Anaerobic Fermenter

The AF serves as a 2-week holding tank in which the accumulated biomass from the SBR is daily discharged too, as well as the periodically removed biomass from the PC and SC. The biosolids suspension in the AF is mixed with injecting compressed air. After 2 weeks the AF biomass is dewatered, followed composting at an off-site composting facility. The produced process water is discharged back into the WWTP for processing. Due to the large Volume of the AF, it is not affected by temperature changes and significant weather events.

The biomass growth experiment was conducted during the month of October and November and stopped due to the low biomass gain on the growth specimens. The reason behind this was the high mixing rate and shear forces by the injected air into the AF that prevented the accumulation and biomass growth on the test specimens.

The total biomass growth, as shown in Figure 10, for the AF was measured at 0.0133 g for PET, 0.0162 g for PE-HD, 0.0208 g for PVC, 0.0163 g for PE-LD, 0.0121 g for PP and 0.0172 g for PS during the evaluation period indicating that PP, PE-LD and PE-HD materials are preferred as biomass growth media.

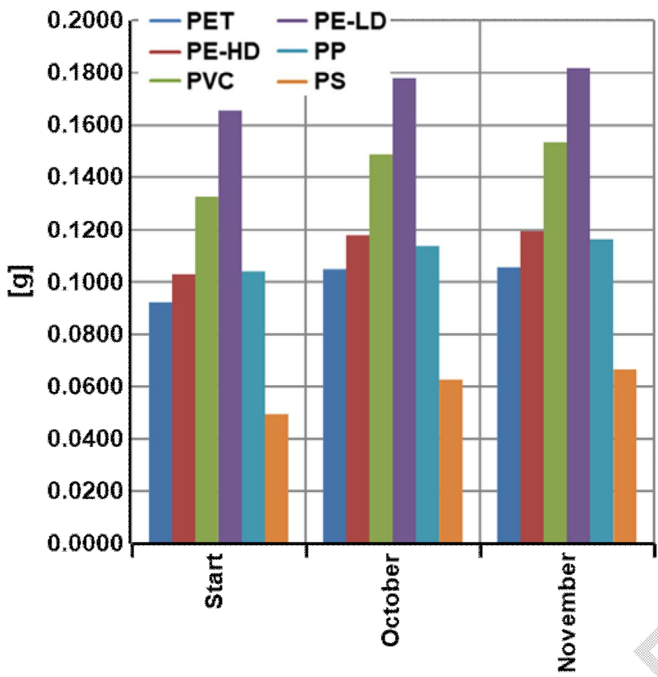

Fig. 10: Anaerobic Fermenter

3.8 Chlorination Station

The biomass growth samples placed in the chlorination station, receiving the treated WW from the SC (Figure 11), and the chlorination station receiving the trea6ted WW from the SBR (Figure 12), show no impact of a temperature change in January due to the weather conditions of frost and snowfall.

The total biomass growth for the SBR chlorination tank was measured at 0.5089 g for PET, 0.8207 g for PE-HD, 0.6069 g for PVC, 0.4421 g for PE-LD, 0.5186 g for PP and 0.2089 g for PS during the evaluation period indicating that PE-HD, PVC, and PP materials are preferred as biomass growth media

The total biomass growth for the SC chlorination tank was measured at 0.0280 g for PET, 0.0817 g for PE-HD, 0.1172 g for PVC, 0.0604 g for PE-LD, 0.0819 g for PP and 0.0822 g for PS during the evaluation period indicating that PVC, PS, and PE-HD materials are preferred as biomass growth media

The significant larger biomass growth of the SBR chlorinating tank compared to the SC chlorination tank can be explained perhaps with a larger amount of nutrients in the SBR effluent water, as well as the design of the SBR Chlorination tank which is designed to hold the entire amount of water discharged by the SBR, releasing it over a specified time, and therefore, allows a higher retention time of the treated WW with the growth media. Whereas the SC chlorination tank is designed as a continuous through flow tank which has a lower retention time of the treated WW, allowing less contact time of the treated effluent with the growth specimens and subsequently resulting in less biomass accumulation on the growth specimens.

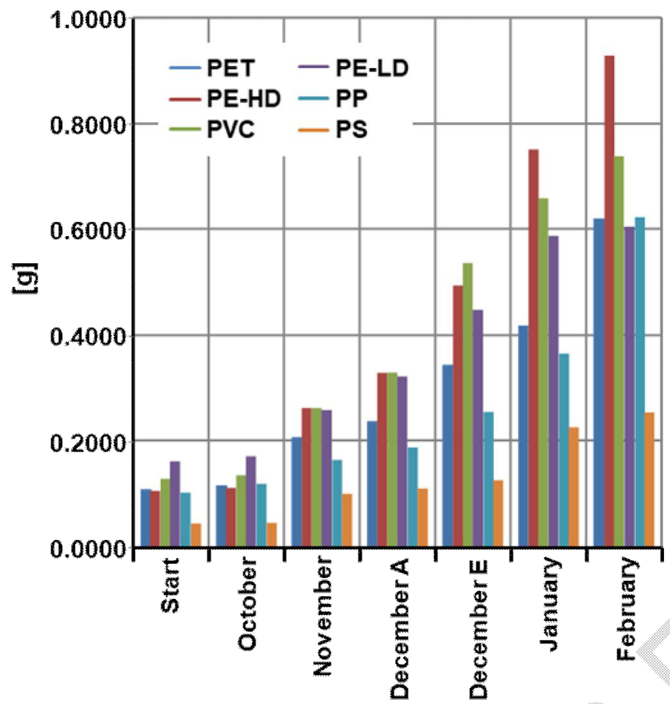

Fig. 11: Sequential Batch Reactor Chlorination

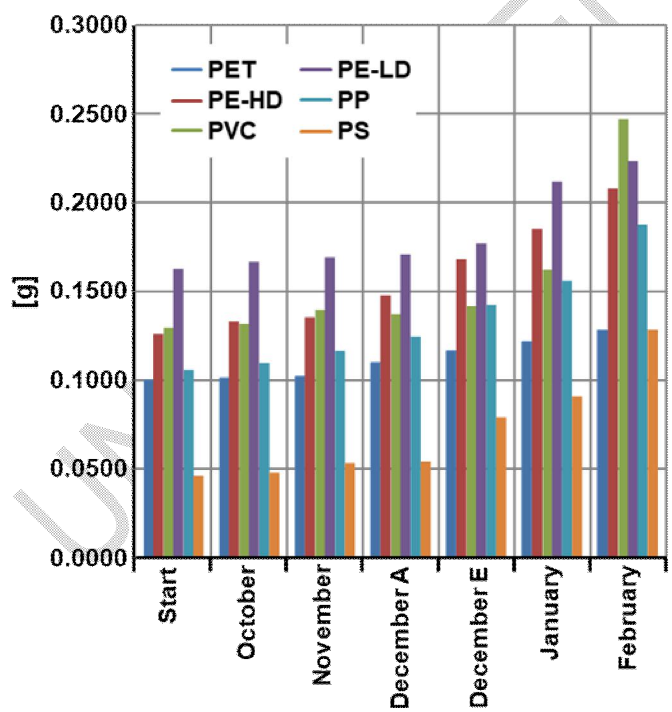

Fig. 12: Secondary Clarifier Chlorination

3.9 Determining Best Plastic Material for Bacteria Growth

Figure 13 shows the tested plastic material PET, PE-HD, PVC, PE-LD, PP, and PS tested for biomass growth in the different WWTP process off: a) Primary Clarifier, b) Distributor Box STFCW, c) Trickling Filter Influent Box d) Trickling Filter, e) Secondary Clarifier, f) SBR, g) Anaerobic Fermenter, h) SBR Chlorination, i) Secondary Clarifier Chlorination.
Biomass growth is noticeable for each test location. However, it is noticeable that each measuring point prefers a different type of plastic material, which in turn is based on the different prevailing processes. Furthermore, it can be seen in the diagram that the Trickling Filter and The SBR Chlorination Tank show the highest biomass gain. The lowest biomass gain was observed in the SBR and the AF, which have high shear forces due to the injected process air for mixing and biomass growth, preventing biomass accumulation on the test specimens. The TF Feed Tank and the distribution Box for the STFCW shoed a modest biomass growth, whereas the PC, SC, and the chlorination tank of the SC showed low biomass growth on the test specimens.

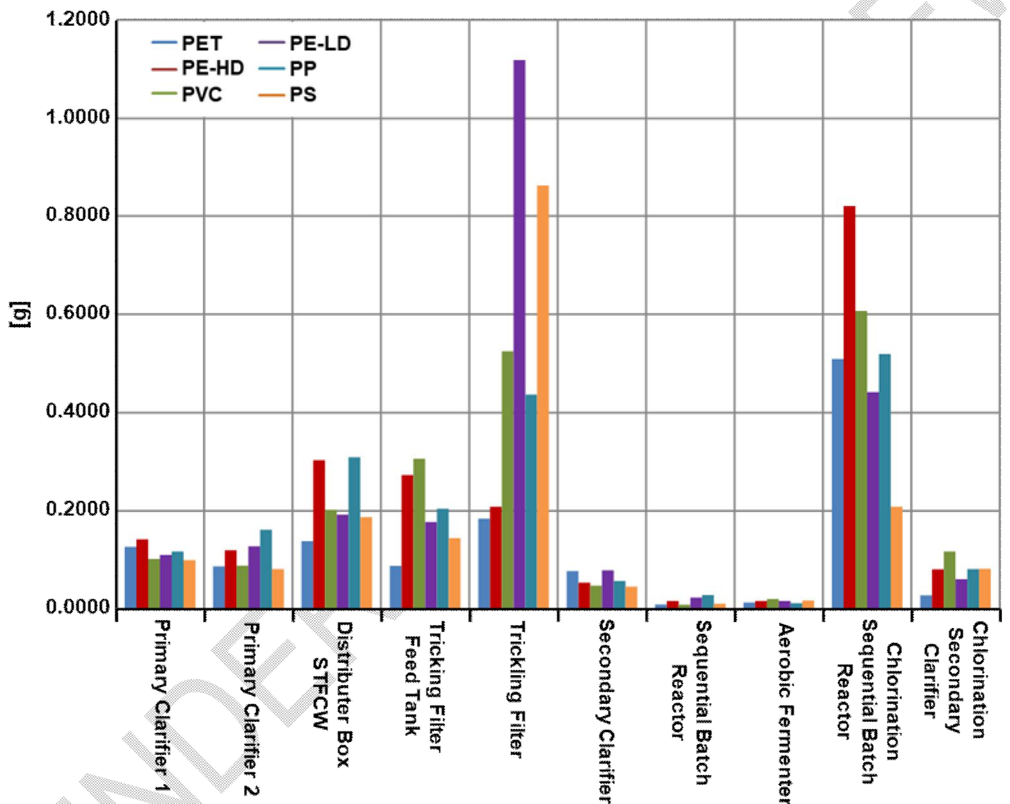

Fig. 13: Combined Biomass Growth Waste Water Treatment Plant

Table 2 gives the three most preferred plastic growth media for the individual measuring points at the WWPT including the measured biomass growth in grams.

Table 2: Preferred Plastic Growth Media

Sample Point	Preferred Growth Media; [Biomass Growth in g]
Primary Clarifier 1	PE-HD [0.1419 g], PET [0.1267 g], PP [0.1175g]
Primary Clarifier 2	PP [0.1607 g], PE-LD [0.1277 g], PE-HD [0.1200 g]
Distributer Box STFCW	PP [0.3093g], PE-HD [0.3034 g], PVC [0.2028 g]
Trickling Filter Feed Tank	PVC [0.3059 g], PE-HD [0.2722], PP [0.2048 g]
Trickling Filter	PE-LD [1.1191 g], PS [0.8631 g], PVC [0.5249 g]

Secondary Clarifier	PE-LD [0.0794 g], PET [0.0779 g], PP [0.0571 g]
Sequential Batch Reactor	PP [0.0283 g], PE-LD [0.0235], PE-HD [0.0161 g]
Aerobic Fermenter	PVC [0.0208 g], PE-LD [0.0163 g], PE-HD [0.0162 g]
Chlorination Sequential Batch Reactor	PE-HD [0.8207 g], PVC [0.6069 g], PP [0.5186 g]
Chlorination Secondary Clarifier	PVC [0.1172 g], PS [0.0822 g], PE-HD [0.0817 g]

Based on Figure 13 and Table 2 above PE-HD is the preferred growth media for seven test locations, the Primary Clarifier 1 and 2 the Distributor Box STFCW, Trickling Filter Feed Tank, SBR, Anaerobic Fermenter, SBR and the Secondary Clarifier chlorination. PP was preferred as growth media for seven test locations, the Primary Clarifier 1 and 2 the Distributor Box STFCW, Trickling Filter Feed Tank, Secondary Clarifier, SBR, and the SBR chlorination. PVC was the preferred growth media for six test locations, the Distributor Box STFCW, Trickling filter Feed, Trickling Filter, Anaerobic Fermenter, SBR and the Secondary Clarifier chlorination. PE-LD was preferred in five test locations, the Primary Clarifier 2, Trickling Filter, Secondary Clarifier, SBR, and the Anaerobic Fermenter. PET was the dominant growth material for two locations, the Primary Clarifier 1 and Secondary Clarifier. PS was the preferred growth material for the Trickling filter and the Secondary Clarifier Chlorination location.

3.10 Suggested Future Research

Future suggested research should focus on applying the primary recycled plastic materials that yielded the best biomass growth for the specific application on: a) Distributor and feed devices, b) Primary Clarifiers, c)Trickling Filters, e) Secondary Clarifier, f) SBR, g) Anaerobic Fermenter, and h) Chlorination processes at the laboratory, small scale field test to verify the presented results followed by large commercial field testing and application.

4. CONCLUSION

Increased environmental awareness requires that waste water streams from municipalities, agricultural and industrial producers are treated in an environmentally sound way by applying processes inspired by nature.

The focus of the presented research performed at the Cleanwater Educational Research Facility, located at the WWTP of the New York Village of Minoa was to investigate the use and application of recycled plastic materials as future growth media for different waste water treatment processes.

Six recycled plastic materials; PET, PE-HD, PVC, PE-LD, PP, and PS, were used for the growth media experiments in the commercial WW treatment process types

Testing was conducted starting October 1st with measuring the test specimens for their biomass growth at a 3-week time interval that allows bacteria to generate a biomass film on the test specimen. The test was concluded in the 2nd week of February.

Biomass growth was observed on all plastic material types at the WWTP measuring points.

Results show that the preferred recycled plastic growth media was PE-HD for PC applications. Recycled PP plastic material was preferred for applications in distributor boxes, PC, and SBR. Recycled PVC plastic material was preferred as growth material in TF, AF and chlorination applications. Recycled PE-LD plastic material was preferred for TF, SC applications. Therefore, future research using recycled plastic material as growth media for biological WWTP processes should focus on these recycled plastic types.

6. COMPETING INTERESTS

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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The author hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

8. REFERENCES

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