# REDUCTION OF GROUNDWATER CONTAMINATION BY CONVERTING PLASTIC WASTE TO PLASTIC LUMBER

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## ABSTRACT

Every year the world generates more than 2 billion tonnes of trash and 79% of the plastic waste is now in landfills and natural environment. These Plastic Wastes break down into micro plastics which seep into the soil and contaminate the groundwater supply. As the rubbish piles up, no number of landfills can keep pace with this growing problem. Re processing the plastic waste to plastic lumber is a useful solution to the problem. Plastic lumber (PL) is a plastic form of lumber (timber) made of virgin or recycled plastic. Plastic lumber is composed of virgin or waste plastics including HDPE, PVC, PP, PS etc. We have used HDPE plastic bottle caps and LDPE bags to make household items like coasters, hand fans, slab, shoe soles, etc. Then we carried out compressive testing. This is followed by the cost analysis as a business model- its feasibility and scalability.

## CHAPTER 1: INTRODUCTION

Every year the world generates more than 2 billion tonnes of trash. About a third of the world's waste is openly dumped or burned. As the rubbish piles up, no number of landfills can keep pace with this growing problem. With COVID overall medical waste increased about 40% due to lack of waste management services. Even as medical waste piles up it's a tiny fraction of municipal solid waste. Of the 2 billion tonnes of waste generated globally 12% is plastic waste. Plastic pollution is the accumulation of plastic in different forms in environment which affects life. This is a major concern among environmentalist and researchers suggests that by 2050 there will be more plastic than biomass in earth. Plastic due to it's versatile nature is extensively used in every field since 1900s but it's chemical composition make it non bio-degradable (20-1000years); above which mismanaged plastic waste disposal is creating havoc. Both incineration and burning presents problems like the production of toxic gases and the residue ash which contains lead and cadmium. A landfill site, also known dumping ground, is a site for the disposal of waste materials. Landfill is the oldest and most common form of waste disposal. Improper disposal of waste in landfills lead to contamination of soil and groundwater. The microplastics and nanoplastics in groundwater have adverse effect on human health. Diminish appetite, tissue inflammation, liver damage, problem related to reproductive system are various observed health issues caused by groundwater polluted by plastics. Thus, the 4R's theory has gained popularity when it comes to plastic waste. 4R's stands for Reduce, Reuse, Recycle and Recovery.

One of such product is Plastic Lumber i.e. Recycled Plastic Lumber which can again be made into various products like doors, garden furniture, desk and bench, photo frames, coasters etc.

### 1.1 Concept of Plastic Lumber

The concept of plastic lumber dates back to 20th century. It came into notice in 1970s when Eduard Klobbie of Netherlands developed a system "The Klobbies Intrusion System" which was based on conventional extrusion and injection processes. The concept of plastic lumber gained momentum in the next decade when technologies were developed by Advanced Recycling Technology, Belgium, Hammer's Plastic Recycling, USA and Superwood, Ireland. After two decades of effort made for equipment design, in 1990s attention was concentrated in composition of plastic lumber and wood-plastic composites. Also, in 1990s for the first time in university level plastic recycling for lumber development began at Institute of Macromolecules of the Federal University, Rio de Janerio. Since then technologies evolved and plastic lumber made it's place in the market.

Plastic lumber (PL) is made of virgin plastic and is called as Recycled plastic lumber (RPL) when made of recycled plastics. Plastic Lumber or Recycled Plastic Lumber is a substitute of timber which can be used for making various items like garden furniture, exterior doors, decking, fences, bed side tables, coasters etc. PL/RPL gained popularity for properties like low maintenance, wear resistant, waterproof, Resistant to cracking and splitting, environment friendly. Plastic lumber is also 100% recyclable unlike wood plastic composites. Plastic lumber or recycled plastic lumber is made different grade of plastic (virgin or recycled) like HDPE , PVC, PS, PP, PLA, ABS etc. which are heated to a temperature of 200-210 degree Celsius to form a dough-like consistency and then extruded to desired shape and size. This process can be carried out with or without additives. Conventional machining process can be carried out of the plastic lumber like cutting, drilling, shaping to get desired product. The only disadvantage of Plastic Lumber is that it is not heat resistant and deforms easily in high temperature.

## CHAPTER 2: LITERATURE REVIEW

There are many methods for recycling of Plastic Wastes. In the report titled 'Methods of recycling, Properties and Application of Recycled Thermoplastic Polymers', author M?d?lina Elena Grigore divides the recycling process in four types; primary recycling, secondary/mechanical recycling, Feedstock/chemical recycling and Quaternary recycling(or energy recovery) in her paper titled "Methods of Recycling, Properties and Applications of Recycled Thermoplastic Polymers" published in 2017. [1]

Plastic Waste conversion to Plastic Lumber would reduce the burden on wood. In their paper titled 'Recycled-Plastic Lumber Standards: From Waste Plastics to Markets for Plastic Lumber Bridges', Dr. Prabhat Krishnaswamy and Richard Lampo mention that the manufacture of Recycled Plastic Lumber (RPL) from post-consumer and post-industrial resins is promising as it consumes large quantities of waste plastics, that would otherwise be destined to landfills, and converts the waste into useful, durable products. Krishnaswamy and Lampo also state that there are certain advantages of Recycled Plastic Lumber over Treated wood. They include resistant to insects, rot, moisture, and many chemicals. Plus, plastic lumber materials are benign to the environment since they do not need chemical treatments to achieve or maintain their properties. The authors also expressed that RPL is also viscoelastic in terms of its mechanical properties. This means that the mechanical properties are time-temperature dependent and subject to permanent deformation (creep) under sustained loads. They are of the view that being able to accurately measure the bending stiffness of the boards, determine creep properties and thermal expansion behaviour and other mechanical properties are required for the design of effective and efficient structures. [2]

With the production of Plastic Lumber the question of its market value also arises. The best approach to gain market acceptance is to focus on performance with these new materials. Thomas J. Nosker and Richard W. Renfree discuss about the same in their paper titled, 'Recycled Plastic Lumber: From Park Benches to Bridges'. They mention that the goal should be to

determine as accurately as possible the lifetime costs of the new material. Many industries are interested investing in alternate materials technology, if it has a larger upfront cost; if it can be proven that the annualized cost will be lower. With most of these materials that do not contain high percentages of degradable organic material, degradation will not be a big issue with the new product. [3]

Thus there are numerous aspects to Conversion of Plastic Waste to Plastic Lumber and our project aims to hopes to be a significant for the same.

## CHAPTER 3: EXPERIMENTATION

### 3.1 Phase 1: Plant Visit

1. Segregation of Plastic Waste: Segregation of Plastic Waste means the separation of plastic waste of different types for the purpose of recycling. Waste is collected from various sources such as industries, waste collection joints, households, etc and thus they need to be separated in order to be recycled. The plastic were segregated based on the type of plastic, i.e., whether HDPE, tetra pack, etc [shown in figure 4.3]. This process is done manually. Then further segregation of plastic waste is done based on the colour and size to aid in the recycling process. For the purpose of collection and segregation of waste we went to the Scientific Solid Waste Management Plant under Swachh Kamakhya Initiative developed by Maa Kamakhya Devalaya.

**2. Shredding of Plastic Waste:** We converted the plastic bottle into flakes using plastic shredder machine which break down plastic into smaller chunks. We collected the shredded plastics for further experimentation process.

**3. Cleaning and drying:**

It is one of the most important step as impurities may lead to deterioration in material properties. Cleaning also prevents odour, germs, sticky substance and dirt. We cleaned the caps and plastic flakes using detergents. And air dried it.

### 3.2 Phase 2: Trials

EXPERIMENT 1: Checking the feasibility of using PET for making plastic lumber.

Step 1: A batch of clean and dry PET bottle shreds were taken and preheated in the laboratory oven at 200?. These were then compressed in the hot press compressing machine at 180? one

plate and 92? in the other.

*Conclusion* : The shredded PET bottle did not clump together to form a distinct product [shown in figure 3.1].

After these failed experiments we concluded that lumbers could not be formed with PET plastic bottles. So we shifted our focus to plastic bottle caps.

**Figure 3.1 : PET bottle sheds after compression**

EXPERIMENT 2: Checking the feasibility of using plastic bottle caps for making plastic lumber

*Step 1*: 36 clean and dry HDPE bottle caps were compressed in the hot press compressing machine at 128? on one plate and 76? in other plate [shown in figure 3.2].

Conclusion: The bottle caps were just melted when compressed together.

Step 2: The output from the previous step was given a spherical shape by hand and compressed it in the hot press compressing machine at 130 ?.

Conclusion: Product was irregular in shape and had uneven surface due to crumbled aluminium foil.

Step 3: New batch of 36 HDPE caps and handful of HDPE bottle neck rings were hot pressed in the hot press compressing machine separately at 136 ? with parchment paper instead of aluminium foil.

Conclusion: Smooth surface sheets were obtained which can be used to obtain desired products [shown in figure 3.2].

EXPERIMENT 3: Checking the feasibility of using polyethene bags for making household product.

*Step 1:* Few LDPE bags were taken and placed one above the other and compressed in the hot press compressing machine at 110 ?.

Conclusion: Formation of a smooth thin sheet [shown in figure 3.3]

**Figure 3.3 : LDPE bags after compression**

### 3.3 Phase 3: Product Development

1. PLASTIC LUMBER

The 0.6mm thick plastic lumber slab is made out of 9 thin sheets of 36 HDPE bottle caps each, hot pressed together in the hot press compressing machine. The slab was shear cut to give the desirable shape. The slab can be made of customised colours or mix colours depending upon the bottle caps available. The slab is hard and durable and can be used to make furniture like garden furniture

**2. PLASTIC HAND FAN**

The Plastic hand fan was made out of one hot pressed sheet of 36 bottle caps. The round shape was given by a shear cutter. The handle of the hand fan was made from a stick collected from the waste. It was attached to the hand fan by tying with a thread. The colour can be customised as per the availability of caps.

**3. PLASTIC COASTERS**

The plastic coasters were made of clean bottle neck rings and bottle caps. Depending on the desired thickness the coasters can be made of 1-3 sheets of hot pressed bottle caps or bottle rings. The colour can be customised as per the availability of caps and bottle neck rings. The required shape and size is given by shear cutter.

**4. SHOE INSOLE**

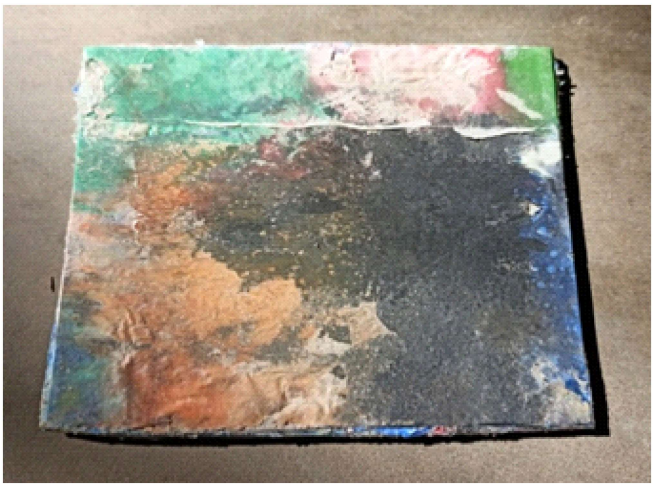
The Shoe insole was made of 5 clean and dry LDPE bags collected from the waste. They were hot pressed in the hot press compressing machine. The resulting sheet was them adhered to a leather sheet of same size. The shape of foot (size 7) was give with the help of scissors.

**Figure 3.4 : Plastic Lumber, Shoe insole, Plastic Coasters and Plastic Hand FanPET bottle sheds after compression**

## CHAPTER 4: RESULT AND DISCUSSION

### 4.1 Testing Mechanical Parameters

ASTM has advanced seven standard test methods that are ways to measure the properties of PL. ASTM D6108, Standard Assessment Method for Compressive Properties of Plastic Lumber and Shapes [4] covers the ascertainment of the mechanical properties of plastic lumber and shapes, whilst the entire cross-segment is loaded in compression at particularly low uniform charges of straining or loading. Compression assessment provides data about the compressive properties of plastic lumber and shapes. We decided to go with this test as for household products compressive test is a good parameter. We decided to perform our test on a compression testing machine [shown in Figure 4.1].



We loaded our specimen [shown in Figure 4.2] on the machine under a load of 200 kN. The material being visco- elastic doesn't show a sharp fracture point. These observations suggest that a corrected cross-sectional area should be used in the determination of the compressive strengths. Since no consistent area correction has been found, the compressive strengths were hence taken to be the compressive stress at 5 percent axial strain for all samples without area corrections. The 5 percent strain limit serves to limit the magnitude of errors associated with the specimen area and provides a consistent basis for comparison of strengths for different specimens. The 5 percent strain limit also serves as a basis for limiting deformation in the field applications. [6]


**Figure 4.1 : Compression Testing Machine**

### 4.2 Readings Taken

i. Initial area (cm2) = 9.5cm*10cm= 95 cm2

ii. Compressive Load (kN)= 200

iii. Final Area (cm2)= 9.7cm*10.1cm= 97.97 cm2

**CONCLUSION:**

Area increased by 1.03 times.

The above data shows that upon applying a load of 200 kN (which is way greater than the general load that will be applied on the household products) the area of the lumber only increased to 1.03 of the initial cross sectional area i.e. 3 percent strain. So the plastic lumber has a compressive strength greater than 200 kN. So our specimen of plastic lumber did not fail the test.

## CHAPTER 5: CONCLUSION

The products developed are still at a very nascent stage but will reduce plastic pollution to a larger extent which in turn will help to reduce groundwater contamination by plastics. It requires a lot of professional inputs to grow into the business that has been envisioned in the future. More study and relentless work are required. The future scope includes:

1. Developing the plastic lumber plant in all the municipalities of the country to achieve reduction of plastic waste volume and groundwater contamination in the truest sense.
2. Using the process of extrusion moulding to make varied other shapes like beams as part of products.
3. Inclusion of other types of plastic wastes such as polythene to develop products.
4. Production of many other types of household items for daily use.

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