Municipal Solid Waste as Building Materials: The Case of Merida, Mexico

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Editor' Note: This paper has been targeted for a broad audience. The level of scientific detail provided is therefore not as high as would be normally be required in technical paper subject to peer review by environment industry professionals.

Wood-Plastic Composites (WPCs)

During the last decades, there has been an increase in the use of materials made of thermoplastic resins loaded with lignocellulosic fibres or particles due to the added benefits that they provide to the materials in terms of lightness, low cost, mechanical resistance, better resistance to moisture, attack by insects and micro-organisms, etc. A few examples of such fillers are sisal, flax, hemp and kenaf fibres. In addition, the use of wood fibres/flours from oak, maple, spruce, pine and fir trees has grown considerably. These materials, the so-called wood–plastic composites (WPCs), are normally extruded or injection moulded into different products with specific transverse sections, designs and geometries to satisfy the needs of different markets, namely building materials, automotive, marine, basic infrastructure, etc. Additional advantages of WPC products over conventional materials such as wood are that they have better dimensional stability, require less maintenance, and have better resistance to decay. The WPC-products market has mainly flourished in Canada, Europe and the US. Reports from 2005 indicate that the production there was over 600,000 tonne per year. In contrast, in Latin-American countries (e.g., Mexico), where huge amounts of wood and plastic wastes are generated, a significant development of this market has not been observed.

The Case of Merida, Mexico

A specific case study is the city of Merida, capital of the Yucatan State in south-eastern Mexico, where solid wastes including wood residues and objects made of different kinds of plastics are produced in quantity. With respect to the wood wastes, many arise from the periodic pruning of branches from the different varieties of trees planted in the city's square gardens, parks and avenues as part of the cleaning and urbanising activities established by the City Council. Other sources are the residues from wood-products manufacturing establishments. These wastes are ground into splinters (reports dating from 2007 indicate that over 300 m^3 were generated every month), and are generally used to prepare compost. At that time, they were piled up in a specially designated disposal site, whose storage capacity rapidly decreased because there was no strict control regarding their exact amount and residence time before their use. To date, it is believed that no important changes have occurred, being that most of this material sadly ends up to the Municipal landfill, wasting in this way its good properties to obtain WPC-based products.

On the other hand, in 2004 it was reported that about 17,800 tonne per month of urban waste (organic and inorganic) was generated in Merida alone, and around 200 tonne per month of different types of plastic objects were reported to be separated from the municipal solids waste at the city's Separation Plant. Approximately 30% of the total amount of plastic waste generated (i.e. about 60 tonne per month) corresponded to different high density polyethylene (HDPE) items, most of which were containers for different products. This situation calls for action to find an appropriate use for these residues in the creation of new materials with practical applications. This, at the same time, would also contribute to partially solving the problems related to excessive accumulation of wastes (e.g. creation of habitats for harmful fauna, and risk of fire during the dry season). Additionally, there is a clear contribution towards protecting the environment, since the use of virgin raw materials for manufacturing common products is diminished. Not less important, all this also helps to encourage the practice of recycling as a culture in society.

Use Waste as Structural Materials

As part of a broad research project involving the study of the availability of wood and plastic wastes generated in Merida and its surrounding regions to be used in the preparation of polymer composites with potential applications as structural materials, we are evaluating their potential for developing constructive elements for housing in the Yucatan State. Because these materials are intended for constructive elements, important aspects that have to be evaluated are their mechanical resistance, their resistance to ultraviolet radiation, moisture and microorganisms attack. Examples of such constructive elements include frames for windows and doors, the windows and doors themselves, dividing panels, fencing, decking, and eaves for windows and doors for protection against sunlight and rain, among many others. Now, the presence of impurities is an issue that really matters during the formulation of WPCs, no matter how advanced is the technology to be applied.

The Challenge of Impurities

In order to obtain a product with the required properties, the raw materials must be as clean as possible. Impurities may cause discontinuous flow during the extrusion of plastic blends, occasioning rupture of the extrudate emerging from the die, affecting the mechanical performance of the resultant product, among many other properties. Therefore, a reliable, good-quality waste management process should be implemented in order to minimise impurities. It may be debatable how advanced the technology should be. The decision is to be taken by the industrialist, and it should be the result of rigorous cost–benefit analyses, taking into consideration the specific application for which the final products are intended, among many other issues. Many procedures could be followed to lower impurities. For instance, visually identifying common contaminants could be a good option. The problem is that the waste can be generated from various sources. This variability usually causes contamination (e.g., presence of dirt, grit, ferrous metals, plastic, glass, etc.). To compete with virgin wood materials in higher-value markets successfully, wood-waste processors must minimize the presence of contaminants in their end-products. A recommended good practice is that operators become aware of the common contaminants that cause problems. This awareness is one of the first steps in achieving satisfactory quality control. Processing facilities should designate inspectors who examine incoming loads before unloading them from trucks. Inspectors should verify that no prohibited contaminants are present. When inspectors find unacceptable material or excessive contamination, they should either downgrade or reject the load

and document its contaminants to communicate proper requirements clearly. Inspectors should quickly become alert to individual generators that deliver certain types of wood-waste containing more contaminants than others. This awareness and subsequent feedback to problem generators can assist them in controlling contamination. Plant operators should have some mechanism (manual or automated) for removing these contaminants. With respect to the plastic waste, similar actions may be implemented in order to separate and classify them by plastic type, looking at the identification code if they have one. It may be useful to classify each type of plastic object by different colours because that would give more chance of having loads of the same kind. Regarding bottles and containers, the best option for cleaning operations may be automation. It should be mentioned that the practices described above are merely recommendations. Other procedures may be required. Again, as mention before, how advanced the technology should be, must be the result of rigorous cost–benefit analyses. To date, flat recycled HDPE-based WPCs extrudates have been obtained at a laboratory level with reasonably good appearance. After exposure to accelerated weathering, cracks over the surface were observed; leaving wood exposed to the environment and creating access routes to insects (e.g., termites). This caused changes in the mechanical properties. Termites constitute a serious threat to WPCs used for outdoor applications because they are able to produce significant changes in their mechanical performance and in their aesthetic appeal. It was found that termite attack was possible only when test samples were previously subjected to accelerated weathering. Although weathered samples were biologically attacked, their effects were only superficial, since their mechanical properties drops were not significant.

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Dr. Ricardo H. Cruz-Estrada holds a PhD in Processing of Polymer Composites with Electro-conductive Properties from Brunel University, United Kingdom. Currently he works as a researcher at “Grupo de Reciclado, Unidad de Materiales, Centro de Investigación Científica de Yucatán” at Merida, Yucatan, Mexico. His main research activities are processing of polymer blends, investigating the microstructure-properties relationship in polymer-based composites, recycling of solid wastes, and applications of wood-polymer composites as building materials.

Ricardo has made a number of publications on his research area and has been involved in a number of research projects one of which was the “Use of Vegetal Wastes for the Preparation of Thermoplastic Composites” funded by the Mexican Council for Science & Technology in 2004-2006. Furthermore, he is a member of The Academic Council of Lecturers of the Postgraduate Course on Polymer Materials and he gives lectures at the “Centro de Investigación Científica de Yucatán” at Merida, Mexico.

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