Review of Management and Economic Engineering
Vol. 22, No. 3(89), September 2023, p. 156 - 169, ISSN (print): 1583-624X, ISSN (online): 2360-2155

QUALITY TOOLS USED TO IMPROVE PLASTIC WASTE IN CONSTRUCTION

Grațiela Dana BOCA [1,*], Gülcan INER[2,*]

1 *Department of Economics, Technical University of Cluj Napoca, 76 Victoriei street, 450122 Baia Mare, Romania, gratiela.boca@econ.utcluj.ro*
2 *Kırklareli University, Vocational School of Technical Sciences, 39100, Kırklareli, Turkey, gülcan.iner@klu.edu.tr, ORCID: 0000-0003-3302-2321*
* *Correspondence: bocagratiela@yahoo.com, gulcaniner@gmail.com*

Abstract: The main challenge today is not plastic, viewed from a material perspective, but the transfer from the linear economic model to the circular model in which goods are produced, used and not disposed of but reused. This model starts from the premise of infinite economic growth and does not take into account the fact that natural resources are limited. There are several ways in which construction plastics can be managed during their life cycle and become truly sustainable products. Quality and price are the elements that complicate plastic recycling. Since plastics are easily adapted to the functional or aesthetic needs of each manufacturer, the diversity of the raw material complicates the recycling process, making it expensive and affecting the quality of the final product. While quality assurance refers to the establishment of standards, quality control refers to verifying that the structures or elements comply with these standards and in the field of construction. Achieving quality standards in construction is an intensive process and long-lasting, for which all participants are responsible. Continuous verification that decisions and work meet predetermined quality assurance standards is essential. Among the methods used to improve the quality in the present study, we will only use the Ishikawa diagram, the fishbone diagram and the 5 M's method. The methods were used in Turkey and Romania to identify the causes and factors that can disrupt the management of plastic waste in the field constructions.

Keywords: plastic waste, construction management, 5M's method, Ishikawa diagram

1 INTRODUCTION

Plastic is a material with multiple uses, today's modern life practically cannot be thought without it. Invented more than 100 years ago, it has proven its value over time; especially when, following the efforts of numerous teams of chemical researchers, different types with different properties were discovered and used. Among them is ABS plastic, a type of polymer that is part of the thermoplastic family, discovered in the middle of the 20th century and introduced to the markets in 1954 by the Borg Warner Corporation. ABS has become very popular and in demand in the production of various electronic devices and equipment.

The first synthetic plastic, Bakelite, was made in 1907 in New York by the Belgian researcher Leo Baekeland who also invented

the term plastic. Very quickly it was found that it is a special material.

Light, cheap, practical and last but not least indestructible, in just a few years plastic has spread all over the world, from bottles to bags, packaging, etc. The most notable quality of plastic is durability. This is precisely where the problem arises, because it lasts indefinitely. But if they are not disposed of or recycled properly, they can end up in the environment, where they remain for centuries and degrade into smaller and smaller pieces (https://echa.europa.eu/hot-topics/microplastics). Given the increase in global demand for plastic, by 2050 we will be producing 4 times more plastic than now.

Unfortunately, this rapid growth, low recycling rates and alarming pollution risks make plastic a major obstacle to a sustainable and healthy transition for our communities.

The solution is not recycling, but preventing the generation of waste.

The responsibility does not belong only to the consumer, but especially to the industry responsible for rethinking and redesigning products so that they are sustainable, non-toxic, repairable and reusable, compostable or recyclable. Products that cannot even be recycled should be removed from the market. Solving plastic pollution requires rethinking how we design, produce, consume and relate to waste in general.

From high-end gadgets to packaging and bags, plastic has been used in many areas over the last century, being easy to produce and cost-effective. However, this synthetic material has left harmful marks on the environment and even on human health. If we pay attention to plastic evolution we can identify different stages of awareness regarding plastic, waste plastic and management plastic became a priority (Figure 1).

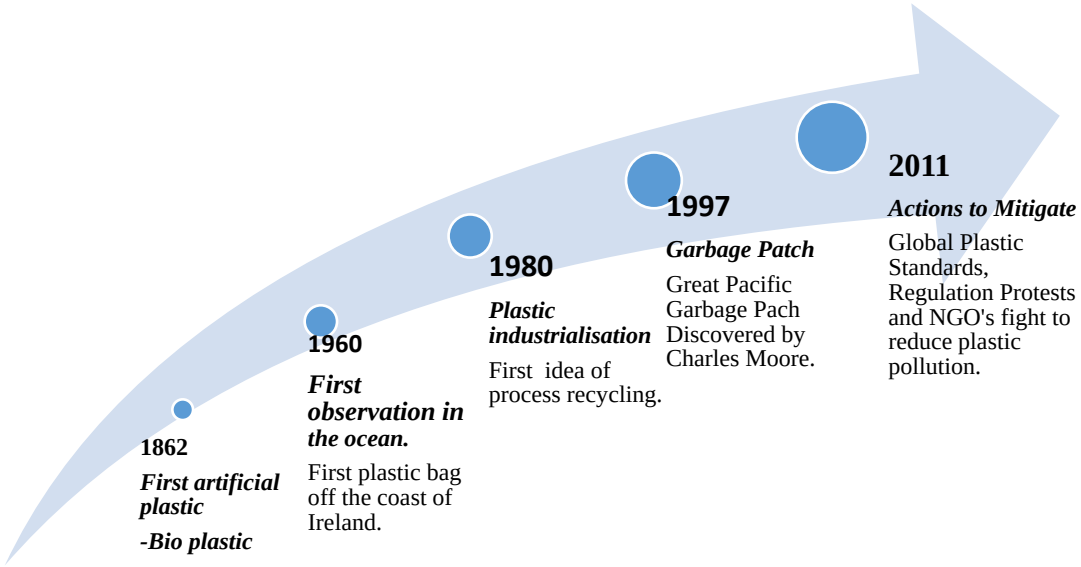

Figure 1. Plastic in time from pollution to awareness evolution

In 1862 at the Great International Exhibition in London (1862). Alexander Parkes demonstrated his invention "Parkensine" which was an organic cellulose-based material. It was the year of revolutionary plastics production.

Pollution was noticed in the 1960s, when people became aware of the environmental problem facing humanity, after the first bag was discover off the coast of Ireland. As technology advanced, the problem of environmental

pollution became important, but together with the storage of plastic waste.

The current problem of eliminating plastic requires time and a series of techniques, but at the same time, bio plastic also brings certain problems, namely recycling and waste storage.

The change in perception regarding plastic materials has changed over time, moving from a positive perception to a more positive one. Initially, plastic represented a solution, but over time, excessive use and in different fields led to plastic pollution of the oceans and the environment.

The 1970s and 1980s brought a new perception of plastic becoming a special target because plastic remains in the environment forever.

In the 1980s, the plastics industry attracted municipalities to collect and process recyclables as part of their waste management systems. Even if recycling is carried out, it is far from perfect, because plastic materials still end up in landfills, which is a problem at the moment. Plastic represents a danger to human health, but at the same time there is a danger of chemicals leaking from plastic into food, water and bodies.

The main objective of a solid waste management system is the effective protection of health, and last but not least of public safety and well-being, an opinion also confirmed by Rebeiz and Craft (1995).

The process of waste management is land filling, incineration and recycling of waste into useful products through a technology. The dynamic character of the quality also led to the development of new construction materials using recycled plastic materials. it is important for both the construction industry and the plastics recycling industry.

In 1997 a yachtsman Charles Moor discovered the Great Pacific Garbage Pach (floating plastics bottles and other debris) which was an alarm signal about the pollution and environment sustainability.

In 2011, actions to mitigate plastic began by implementing global standards specifically for plastic, regulations that use plastic symbols, and the implementation of the 3Rs, which have slowly become the norm.

Despite growing mistrust, plastic is essential to modern life. Plastic materials have been the basic material in the new field of computers, generations of high-performance mobile phones, but also in the field of modern medicine. Without plastic, many goods we take for granted could be within everyone's reach. The increase in demand for products led to the appearance of plastic, which resulted in the appearance of cheaper, lighter, safer and stronger products, but which currently represent a danger and require replacement with biodegradable materials.

The new innovations led to the discovery of bio plastic that degrades over time because they have as raw material plants being more ecological than conventional plastic.

Scientists are looking for innovative solutions, ways to make plastic recycling more efficient and even hope to perfect a process that turns plastic back into fossil fuels. Plastics aren't perfect, but we find them everywhere, they make art of our lives that's why necessary to find a solution for the future.

The construction sector is extremely active in Romania and Turkey, but it intensively produces scrap materials. In general, these residues are generated as a result of construction and demolition activities, and most of the time they are non-biodegradable and end up overloading landfills. Moreover, some of them fall into the category of hazardous waste both for human health and for the environment. Therefore, they must be separated and managed according to the legislation in force. There are many industries producing waste, but that of construction is the most widespread, and because of this the environment is seriously impacted. Any harmful substance such as heavy metals, nitrates,

sulfates or incompletely burned ones can infiltrate the soil and in this way progressive pollution develops. When they are not taken over by a specialized company, they end up in the landfill, where they are not treated and processed differently, which eliminates any chance of waste recycling. Such residues not only pollute the soil, but also water and air.

In both countries, any construction company is obliged to sort, recycle and dispose of the waste found on the construction site, and most of the time, this activity is quite complicated. That's why they have to turn to a company specialized in the field that can make the process more efficient.

The collection of industrial waste from construction and demolition must be selective. It is important that hazardous waste be separated from non-hazardous waste and, depending on the harmful potential, be eliminated or put back into circulation as raw material.

Therefore, these scraps must be managed as responsibly and professionally as possible. The process starts from the collection of waste, its transport and management in a way that does not affect the ecosystem. Including the disposal and evacuation of debris is an important step in protecting the environment.

1.1 Plastic in construction

Plastic materials are also used in the construction industry due to their durability and profitability but also energy efficiency, safety and ease of installation. Some companies like Palram (https://www.palram.com/blog/construction-architecture/plastic-waste-in-construction/) are already successfully applying plastic:

- PVC and polyethylene wall and floor cladding because they wear less;
- Polycarbonate sheets and PVC sheets are used for roofs and skylights;
- Insulation with polyurethane foam;
- Walls, roofs and doors are insulated with polyurethane or polystyrene.
- PVC and PE are the most common materials used in pipes there are only some uses.

In comparison, the industry where metal parts are replaced by plastic in a construction project is usually used less. However, plastic contributes to a lighter construction and to the reduction of the use of heavier elements.

Today, important concepts such as reducing environmental problems, resource conservation and energy efficiency, and sustainable development have also entered the agenda of the construction industry.

In the field of construction, it must be taken into account that the construction materials used in a building have a life cycle affected by approximately 10% due to the impact on the environment.

Taking into account the importance of materials and the impact on the environment, reusable and/or recyclable materials in the construction industry, which have a lower impact, were used as a solution in most cases.

Sev and Görgülü, (2012) showed that the prevention and uncontrolled release of structural waste from the construction sector and the pollution of soil and water resources can be controlled by using new types of materials.

The construction sector shows positive numbers when it comes to plastic waste generation and plastic waste management.

There are two reasons for this: product life and waste management.

The construction industry is the main actor in the economy of any region. Lamb et al. (2022) in their study paid attention to the importance in the construction field of modifying bricks/tiles/masonry blocks by replacing them with plastic waste. Plastic waste can be used in the construction industry to make bricks, tiles and building blocks. Another area would be in road construction, as Lamba et al. (2020)

maintained that the improvisation of concrete using plastic is already in practice in different parts of the world.

At the same time, Al-Sinan et al. (2022) addressed innovative practices for managing plastic waste in a circular economy that have gained momentum and replace plastic with new alternatives.

We can give thus another example from the cement industry which represents the largest source of CO2 emissions, which represents a challenge in the field of plastic reuse and in this field.

Figure 2 presents sustainability in construction and life cycle assessment and civil engineering.

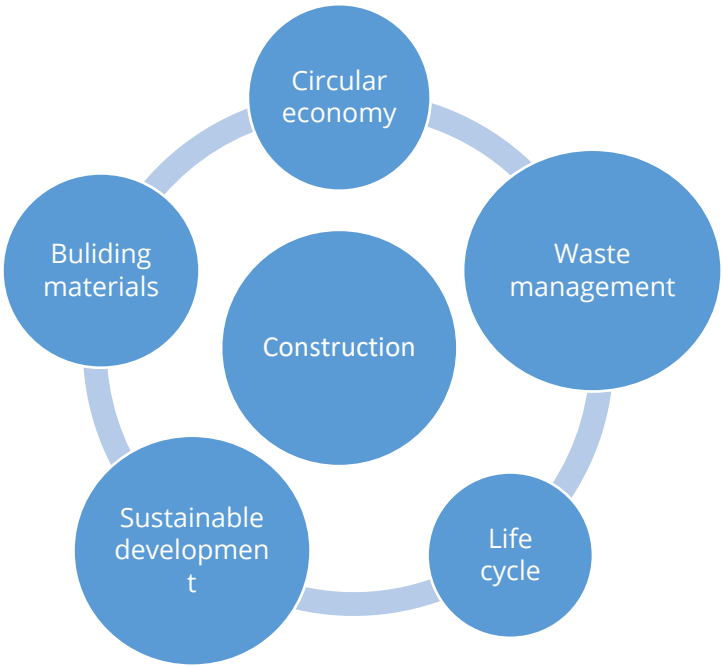

Figure 2. Relationship between lifecycle assessment and construction sustainability

Waste represents in Liyanage et al. (2019) opinion a challenging problem related to the environment, the economy and obviously also the social environment.

One of the principles of quality management is "Zero Waste" which by translation is also a solution for waste disposal, reuse or recycling.

Singh and Ambika (2022), for their part, observed that solid waste has accelerated worldwide and has become a major global environmental problem. They highlighted the need for a sustainable strategic waste management system to prevent further depletion of these natural resources through a "zero waste" approach.

In waste management; reuse is the reuse of waste in the same way without any treatment other than cleaning. Recycling is “reuse and recycling”. It is the process of using the wastes more than once by using the properties of the wastes, including the concepts of conversion.

As a sequential process, the collection, processing and reuse of waste constitute the recycling process. (Tandoğan,2018). Unfortunately, the majority of plastic waste in the world cannot be recycled and reused.

Innovative tools to eliminate waste rather than managing it through landfills. However, turning over-consuming activities into zero waste is still a challenge.

When solid waste disposal methods are evaluated in terms of cost, the least costly method is the reuse of waste, since no reprocessing is performed. In the construction sector, important studies have been carried out on the reuse of wastes without any treatment.

The use of plastic bottles in the construction of residential walls by reuse https://www.boredpanda.com/plastic-bottle-village-house-pollution-robert-bezeau-panama/?utm_source=google&utm_medium=organic&utm_campaign=organic)

Examples can be given such as using waste plastics in building bricks by converting them into masonry bricks. (https://impakter.com/how-homes-made-of-plastic-waste-can-solve-a-double-crisis/).

Michael et al. (2022) have also added rural areas to the circular economy of plastic waste recycling.

In the Nordic country, Sweden for example, prominent musician's record songs and commercials are televised to encourage people to return used bottles for recycling(https://www.trtworld.com/europe/swedish-recycling-so-successful-it-is-importing-rubbish-24491).

A pleasant recycling experience is the loudspeakers that play music when you place the waste. Another solution to encourage the recycling plastic in supermarkets, for people is the deposit of bottles and cans in exchange for money, in a practice called "panta", which is growing step by step in all countries.

Global Recycling Day it is celebrated on March 18 every year, to encourage the recycling initiative and to look at our trash in a new perspective (https://www.facebook.comgovernanceinalbania/photos/a.421995741478811 0/4958674967583014/?type=3).

Forcael et al. (2020) pointed out as the construction industry faces changes in its processes and working methods, and the progress of new technologies in recent decades has led to a new concept known as Construction 4.0. Four technologies are essential to understand construction 4.0 today: 3D printing, big data, virtual reality and the Internet of Things.

But we must also specify the reuse of plastic as a beneficial solution for construction specific innovative tools: devices, information technology and materials are additional elements of Construction 4.0.

Huang et al (2022) observed the interdependence between Industry 4.0, and Quality 4.0 (Q4.0) which focuses on digital technologies that integrate social and technical resources and provide its customers with the best possible product and service.

da Silva et al(2021) investigated waste management, which is largely absorbed by the civil construction sector. They looked at plastic waste, which can be incorporated with construction materials such as concrete, mortar, asphalt mixes and paving. Recycling is also a tool that allows improving the long-term sustainability of products and processes.

de Almeida Barbosa et al. (2022) mention the insertion of Industry 4.0 technologies which can be used in civil construction with help of sensors, robots, artificial intelligence and drones to bring a new added value by improving productivity, efficiency and environmental safety of constructions and become more sustainable.

Oberti and Paciello (2022) showed that bio plastic has proven to be a viable substitute for plastic materials and their use in construction.

Huang et al. (2022) in their study investigate also the social and technical impact of Quality 4.0 (Q4.0) on Industry 4.0 (I4.0) technologies and as an example of circular economy good practice.

This paper reviews recent studies on the development of plastic sand bricks and the different percentages of plastic and sand used in bricks.

Such studies are essential for the industry to invest in and adopt this alternative building material. Plastic sand bricks could be a viable solution to combat solid waste problems. In this paper it allows us to look into the perspective of some specific technical needs, the practical implementation of emerging technology and new ideas to reduce plastic pollution.

2 METHOD AND TOOLS

Quality assurance covers things like:

1. ***Materials used:*** Are they of the right standards, the right size, shape and materiality?
2. ***Equipment:*** Will they work in the given environment, are they safe?
3. ***Agreed methods*** of measuring quality: What does this 'look' like?
4. ***Project Management:*** Timeframes, fair bidding processes, agreed budgets, etc.
5. ***Qualifications and Skills:*** Do the people involved have the right skills for the jobs required?

So quality assurance is about preparation. By keeping quality in the decision-making process of your projects, you can be sure you're purchasing the right materials, using the right equipment, and that everyone knows what to expect. Achieving quality standards in construction is an intensive and long-lasting process, for which all participants are responsible. Continual verification that decisions and work meet pre-established quality assurance standards is essential. Among the methods used to improve quality in the present study, we will only use the Ishikawa diagram, the fishbone diagram, the 5 M's method.

2.1 5M's method

5M's method used to determine factors which can influence waste plastic like construction and industry sectors. It is easy to identify first important 1M's people = man who are involve in waste plastic process like in Figure 3.

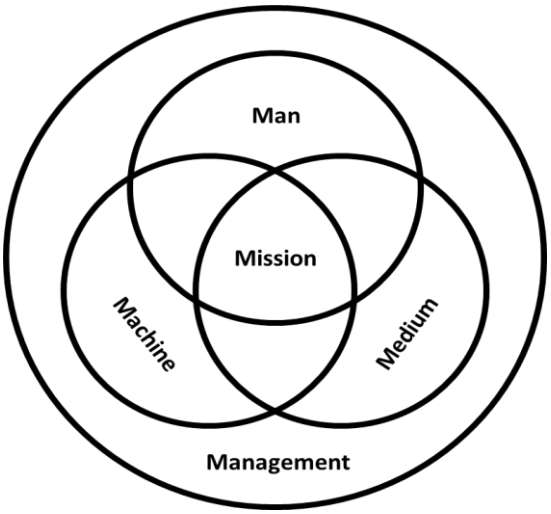

Figure 3. 5M's in construction management

Source: https://en.wikipedia.org/wiki/5M_model

The second 2M's = machine necessary to transform the raw material in products.

The 3M's medium = the impact of man and machines can influence environment in a positive or negative way regarding: carbon print pollution CO_2, sound pollution or waste plastic putting in danger nature.

Also from Figure 3, we can identify the 4M's = management because the three factors depend of the human skills and competence and capacity to combine the factors to obtain on the final 5M's = missions is to increase waste plastic.

But because of the dynamic character or quality it is important also to pay attention to money, and according to waste plastic the cost is influencing the final product.

As we can see now and days waste plastic it is used in construction for bricks, for roads, for different parts of building to reduce the heavy, etc.

2.2 ISHIKAWA diagram (Fish- bone diagram)

Another tool used to improve quality management it is the cause-effect diagram which was designed by the Japanese Kaouru Ishikawa in 1986 and is known under various names fishbone diagram or Ishikawa diagram.

By its configuration, the diagram allows highlighting and ranking the causes which generates a certain effect.

The diagram was developed to determine the main causes of a given problems.

It is recommended to use it only when there is only one problem and the possible causes can be ranked.

The cause-effect diagram has two parts:

Effect - part of the effect;

Causes - part of the causes-effects.

The effect (a particular problem or feature /quality condition) represents the "head of the fish" in our case will be the waste plastic in industry and construction sectors.

From theoretical point of view we identify the effects which are characteristics for following elements labor problems, costs, production, delivery, job security, etc.

The effects are concretized in the evolution of the level the parameters characterizing the process under way the analysis in our case waste plastic and the study establish the causes.

Potential causes and sub-causes emerge "bone structure of fish". Causes are the factors that determine the effects, the occurrence of a given situation. The causes can be different depending on the specifics the good analyzed.

Dispersion of the characteristics of a product, by example given by Blaga (2020), can be determined by the existence of some causes such as: defects in the raw materials used, adjustment differences in the machines on which process, workmanship mistakes, the methods of execution organization, the environment in which it takes place activity.

The diagram classifies the various causes that believe it affects the results of an activity, marking with cause-effect arrows between them.

The Ishikawa diagram is a management tool that establishes a cause-effect relationship between different elements. This is used for quality control, helping to identify the root causes of problems or defects found within a company's operations.

The diagram in this form cannot provide the necessary solutions, but only allows a clear definition of the studied problem.

Being used as visual support during the brainstorming session, the diagram is meant to stimulate the imagination participants in search of ideas by which to solve the analyzed problem.

The main objective of the Fishbone diagram is the graphic illustration of the connection between a result and the factors that led to its appearance.

The main objectives of this tool are:

- determining waste plastic using the root causes associated with a problem ;
- focusing on a problem, avoiding irrelevant discussions;
- identifying areas where information is insufficient (construction, industry).

A business is always faced with the difficulty of solving specific problems.

Business analysis is usually done to identify difficulties, their underlying causes and the subsequent effects that occur if the problems are not resolved (https://harappa.education/harappa-diaries/cause-and-effect-relationship/).

Whether it's analyzing a failing product line, implementing appropriate management policies, or determining the best production methods, establishing a cause-and-effect relationship is vital to any process. This helps

achieve the desired business results, allowing the manager to identify and address the root cause of a problem. The cause-effect relationship in management involves the analysis of past problems and mistakes (https://harappa.education/harappa-diaries/cause-and-effect-relationship/). It also aims to identify risk areas in the past and to avoid them in the present.

A business analyst will always seek to establish a cause-effect relationship in order to propose viable solutions.

Diagrams designed for problem solving, known as Fishbone Diagrams, can be implemented in all aspects of a business to understand causes and analyze possible effects in our case will be used to determine the effects- causes for waste plastic used in construction.

3 RESULTS

The construction industry has developed a lot in the last period, but to the same extent it also has the greatest need for raw materials.

Therefore, from recycling; the sector that will benefit the most in terms of energy, reduction of raw material consumption, waste limitation and utilization is the construction sector.

A cause-and-effect relationship implies that, in order to solve a problem (or manage an effect), an organization must identify the causes behind the effect.

For that reason we start to identify in industry and construction the waste plastic problem and as effect and identify the possible causes.

Discovering all the causes will help the organization from both sectors to solve the problem and plan how to prevent its recurrence.

Blaga (2020), mention all these causes, known as "the 5 M's", are ordered by category and graphically visualized in the form of a fish skeleton.

The 5 M's identify for industry management are:

1. Materials;
2. Man;
3. Machinery;
4. Micro medium;
5. Method to measure;

but because of quality evolution we adopt other three M's:

6. Money;
7. Management;
8. Market.

In construction management field like in Figure 2 we have:

1. Machines;
2. Man;
3. Materials;
4. Micro medium;
5. Management;
6. Money;
7. Mission.

The branches of the cause-effect diagram indicate the relationships that can be established between the effect and the potential factors as causes:

a) is used when the problem to be solved cannot be located within one department / section / division;

b) of process in order to identify the causes potential problems identified in each stage of the process;

c) as a whole, then it is identified sub-processes or steps of the process that will be analyzed separately;

d) within each stage /one diagram can be used per sub-process 4M / 5M / 6M / 4P; the causes are thus identified key, which will be subject to an analysis subsequent.

In Figure 4, we identify for our fish bone diagram in construction field starting from effect = plastic waste, and identify the causes= the M's.

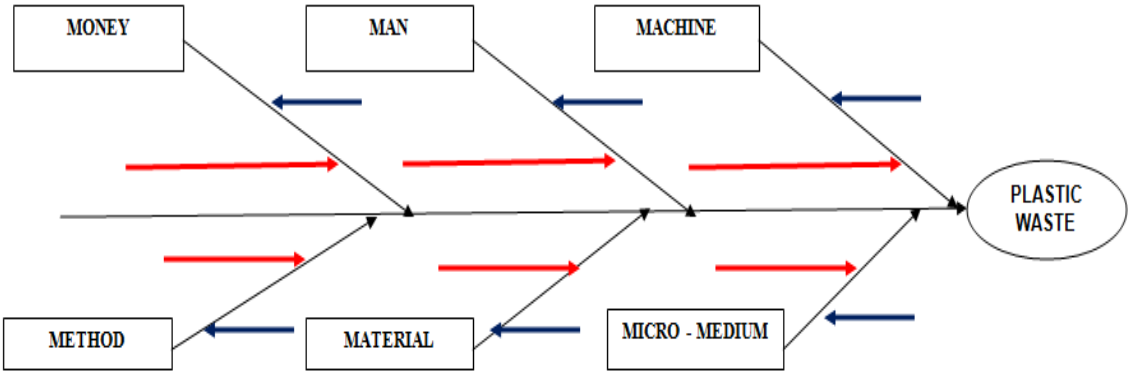

Figure 4. Fish bone diagram for construction

For construction we can mention the following M's: Money, Man, Machine, Method used in last period, Material used and Micro-medium.

In red color we arrow we will specify the internal factors and in blue color the external factors which can influence the quality management and also the construction quality.

In Figure 5 we present also factors which can perturb the cause.

M1- Money it is an important cause taken in consideration that the new materials used in construction are expensive, so choosing cheap material.

Currently, recycling in the construction segment is almost insignificant.

A major advantage of a possible orientation towards the use of recycled plastics in the field of construction materials is the significant decrease in the pressure on the demand for natural resources and the replacement with recycled plastic bricks of the PET, PP and PE type, to which other products are added natural, such as hemp, sawdust, clay and concrete waste.

M2- Man –person involve in managerial and working staff, can be also an important cause which can influence the plastic waste:

Use a lot of plastic;

Easy to use; Easy to get;

Not squeeze plastic bottles;

Don't know; Don't care;

Lazy to use packaging that can be refilled;

Want to be practical.

3 M- Material another cause which must to be taken in consideration:

Unrevealable quickly;

Chemical structure cannot be decomposed;

Waterproof; Light;

Durable; Robust;

Recovered.

Some companies sign contracts with sanitation services regarding waste collection, but the negative side are that they are not sorted by type of material, so that they can be further recycled and utilized.

The same applies to hazardous and non-hazardous residues, which leads to the contamination of the latter.

They do not reach authorized warehouses, but are stored illegally.

Unfortunately, companies do not pay enough attention to waste management from demolitions and constructions.

In Figure 6, we present the new M's causes for fish bone diagram (Ishikawa diagram) for plastic waste in construction sector.

Rybak-Niedziółka et al. (2023) in their research work mention some good practices of construction and demolition companies:

- avoiding the use of much too large quantities of raw materials;
- the most calculated and exact use of building materials;
- the use of recycled materials;
- the use of environmentally friendly technologies and finishes;
- return of packaging to suppliers for recycling and reuse;
- avoiding the destruction of materials on the construction site, in order to eliminate the additional purchase of raw materials;
- carrying out controlled demolitions that allow the recovery of certain materials.

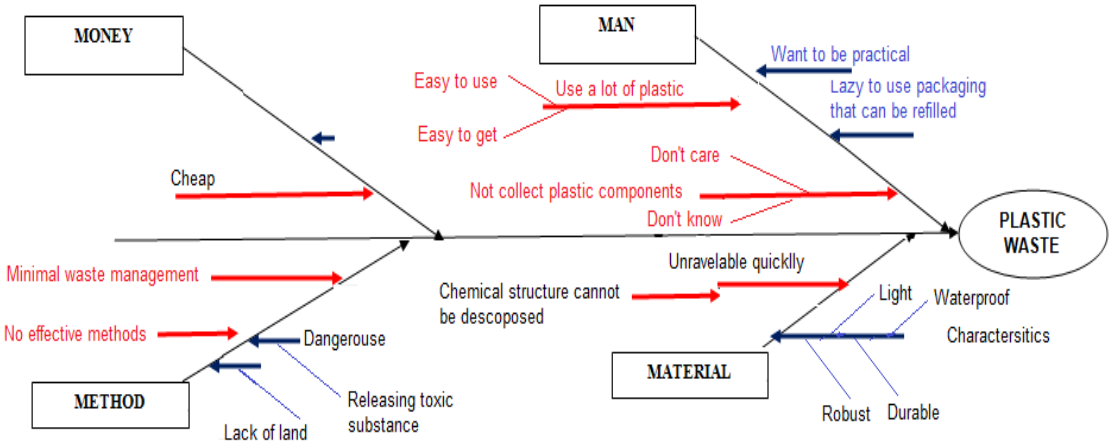

Figure 5. Fish bone diagram factors which influence the construction plastic waste management

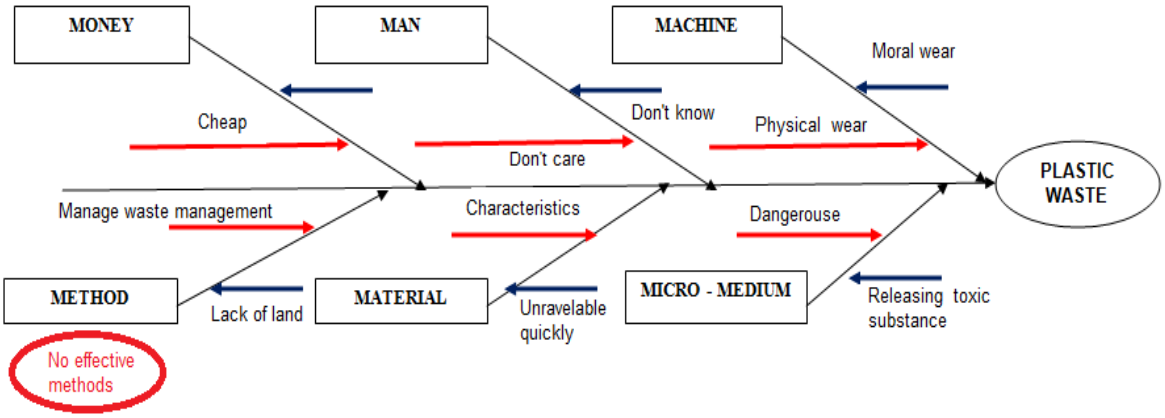

Figure 6. Ishikawa diagram for plastic waste

4M-Methods used to minimize waste management can be considering an important cause which can be influence by some possible factors:

- Lack of land;
- Releasing toxic substance;
- Dangerous situation;
- No effective methods used;
- Lack of information.

Because the dynamic character of quality another M's were taken in consideration in construction sector, for increasing the quality management, and decrease the plastic waste.

5M- Machine – we know that machines can be influence in time by moral and physical wear so the new generation of tools are important for environment not to be and to polluted the environment or to produce damages.

6M- Micro –medium management the micro medium it is important because the waste plastic must to be recycle and then to be reused, so good management can bring a positive action in plastic waste.

CONCLUSION

The study wants to present some methods of improving plastic waste management by using easy-to-apply methods.

The use of plastic waste for bricks, roads, is a start that with Construction 4.0 will certainly bring new methods and tools while at the same time protecting the environment.

By replacing the plastic with new biodegradable plastic also in construction field it is possible to decrease the impact of plastic waste.

The benefit of using biodegradable plastic materials or bioplastics consists in the fact that they are made from natural plant-based raw materials that allow a natural decomposition process.

The process of decomposing plastic waste continues by turning it into compost after a certain period of time.

Biodegradable plastics are used in many areas shopping bags, the medical department bottles, tea bags, jars, air pillow, pens, pencils sharpeners, etc.

We can mention some reasons to use biodegradable plastic:

- ✓ Save non-renewable energy sources;
- ✓ Reduces carbon emissions;
- ✓ Low energy consumption;
- ✓ Provides an ecological solution.

Biodegradable plastic is of great importance because it helps the environment by eliminating waste, helping to create a greener and more sustainable future for our planet.

Some of the advantages of biodegradable plastics materials are:

- ✓ Reduce carbon emissions;
- ✓ Consumes less energy;
- ✓ Less storage space;
- ✓ They can be recyclable.

Bio plastic as a material has recently become an original model that attracts attention and that in the future ensures that carbon emissions are reduced, and house constructions can be beautiful multi-colored and not shaded.

As we presented in the case study, waste management requires the management of construction waste, which translates as follows:

- Setting up a special space for the selective collection of waste;
- Signing contracts with authorized collectors;
- Appropriate labeling of each category of waste;
- The preparation of the evidence of waste management during the entire duration of the project;
- Ensuring a degree of preparation for reuse, recycling or other recovery operations.

In conclusion, the Ishikawa or fishbone diagram can be used when there is a problem and you want to identify the possible causes.

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