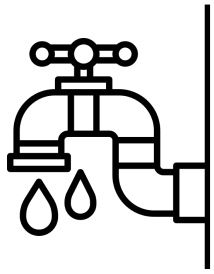

Eco-auditing Project

Drinking Water Pipes

[redacted]

Project Statement

On the authority of the World Health Organization's 2017 report, safe drinking water is defined as water that does not represent any significant risk to health over a lifetime of combustion, including different sensitivities that may occur between life stages. In the aspect of clean water and sanitation of SDGs, there is also a target that aims to achieve universal and equitable access to safe and affordable drinking water for all by 2030.

The quality of drinking water is closely associated with a building's piped distribution system. Meanwhile the materials of pipes used to transport drinking water are different from those used to deliver wastewater or other plumbing systems. The materials of pipes for the potable water supply in a household plumbing system vary over time.

A pre-1970s house may have galvanized water lines that use steel or iron pipes with a zinc coating. But galvanized pipes are vulnerable to internal rusting and mineral deposits over time which might negatively affect human health. As a result, copper gradually replaced galvanized piping and then was widely used in the latter half of the twentieth century. However, the use of copper pipes has decreased due to the dramatic increase in the price of copper, resulting in increased demand for alternative products including PEX and stainless steel.

PEX is cross-linked polyethylene, which well meets the requirements of potable water distribution service due to its competitive pricing, ease of use, resistance to a wide temperature range and corrosion, as well as good performance in durability, compared to other plastic pipes such as PVC, CPVC.

In the next section of assessment, through eco-auditing, the sustainability and performance aspects of different materials of potable water pipes will be analyzed based on a household scenario, as well as their contribution to the environmental and economic sustainability.

Prime Objectives and Scale

These are defined in the project-statement. The prime objective is to compare different materials of drinking water pipes - galvanized, copper, stainless steel, PVC and PEX - from the perspectives of prices, durability and their environmental impacts to provide a better selection basis for ordinary people. The scale would be limited to the household level.

Stakeholder and Their Concerns

The primary stakeholders are domestic households who are the most direct users of drinking water pipes. Household life is closely associated with daily water use. People are caring about the quality and the use of potable water pipes because they play an important role in water quality that greatly influences human health.

The secondary stakeholder would be the pipe makers and their suppliers. As regards the environmental footprint, the manufacturing phase can not be omitted. Their concerns include the materials sourcing, production costs, commercial profits, distribution and carbon footprint that production emits.

Governments concern the operation of potable water supply as well as the pipes manufacturing. They pass relevant policies and regulations to encourage the production and the use of more environmentally sustainable pipes.

NGOs appeal to society to focus on drinking water quality and the appropriate use of pipes for delivering drinking water, and promote preventing repeated pollution.

Fact-finding

- **Economic aspects - prices (EUR/m³)**

From Figure 1, we can see that the prices of 6 main pipe materials per unit volume. Metals such as copper and stainless steel are the most expensive materials with prices over 15000 euros per cubic meter, while plastic materials and galvanized is much cheaper which range from around 2000 to 7000 euros per cubic meter.
Hence with the same length, the cost of metal pipes is higher than plastic pipes.

Galvanized pipes: Coated steel, steel, galvanized
Copper pipes: Copper, C14200, hard (phosphorus de-oxidized arsenical h.c. copper)
CPVC pipes: PVC (chlorinated, molding and extrusion)
PVC pipes: PVC (rigid, molding and extrusion)
Stainless steel pipes: Stainless steel, austenitic, AISI 302, annealed
PEX pipes: PE (cross-linked, molding)

- **Tensile strength (MPa)**

Metal and galvanized pipes perform better in bearing the water pressure without breaking. Plastic pipes are relatively weaker but satisfy the demands for delivering drinking water.

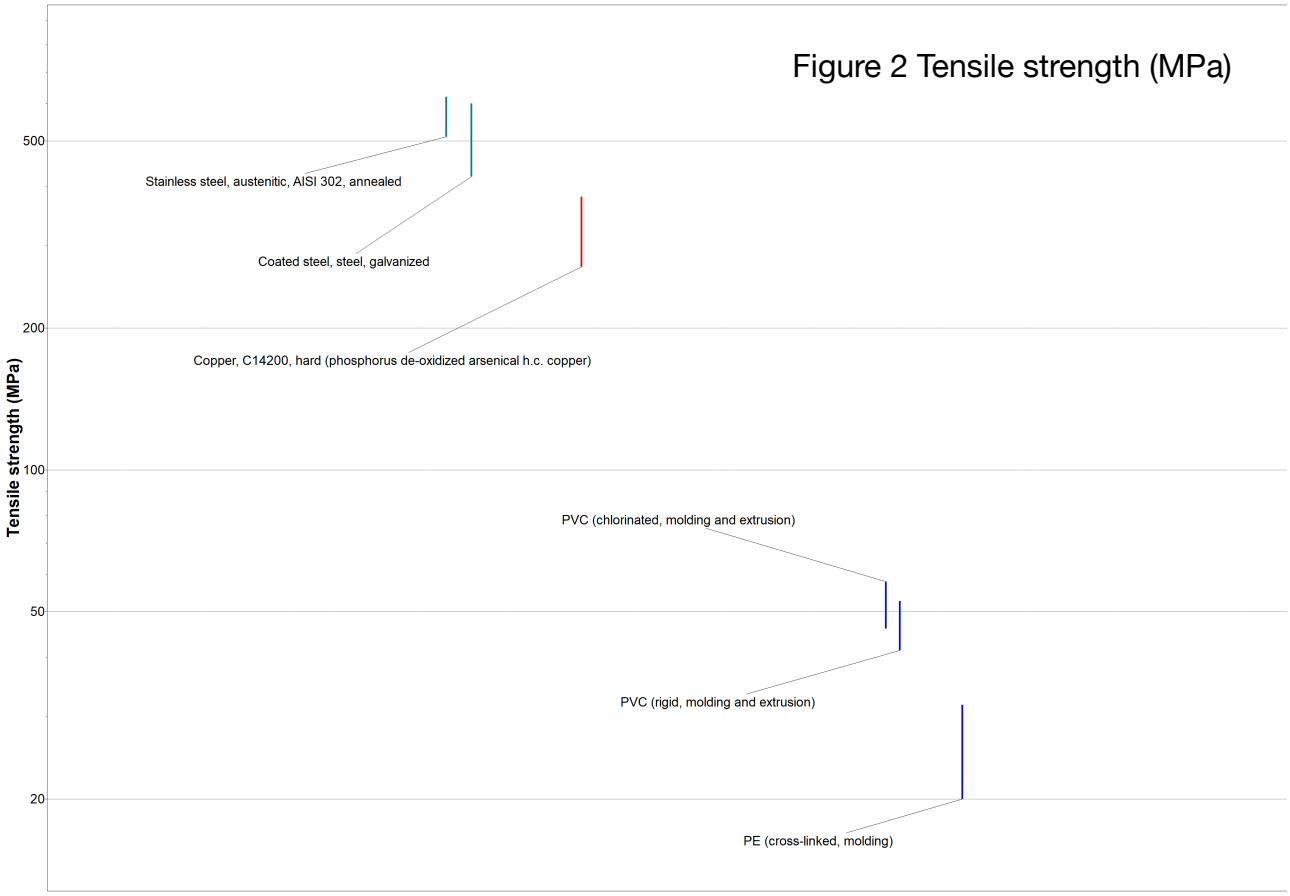

Figure 2 Tensile strength (MPa)

- **Maximum service temperature and minimum service temperature (°C)**

With maximum service temperature down to 50°C, PVC can not be used in transporting hot water. Furthermore for cold water, the lowest temperature of water that PVC can carry is close to 0°C, which may cause potential safety hazard as well.
Metal and galvanized pipes is highly capable of delivering cold and hot water.
Other plastic pipes are well acceptable to potable water transport.

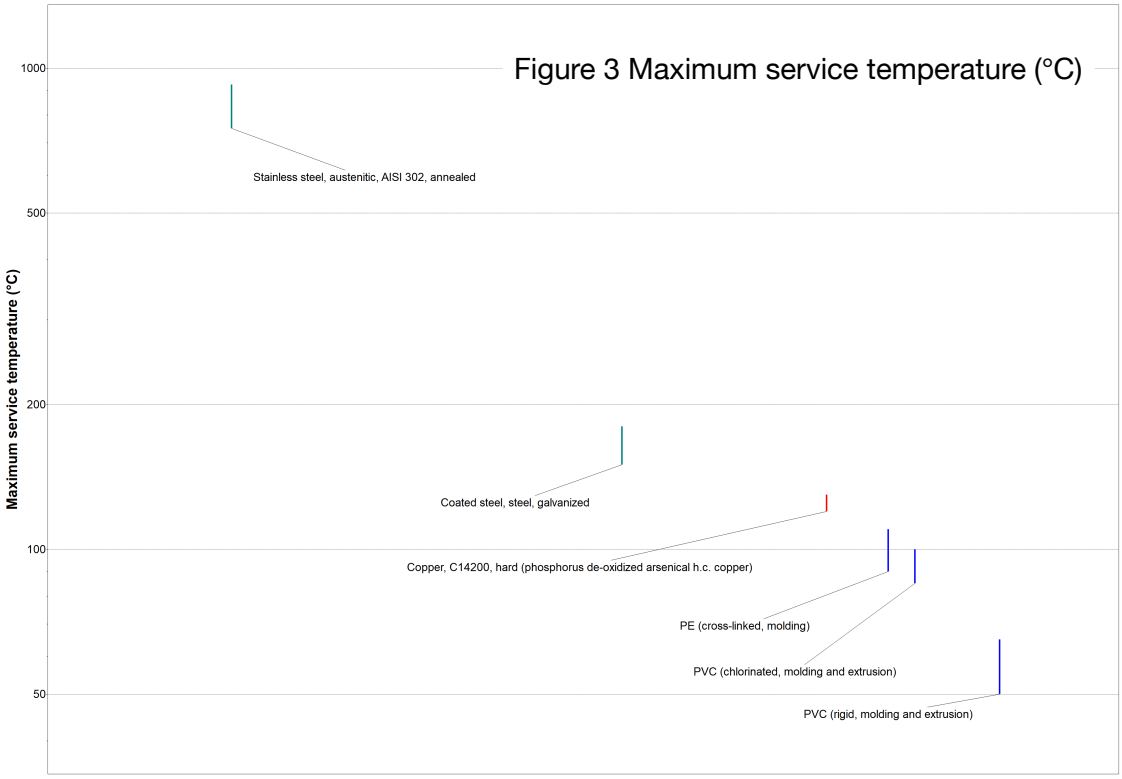

Figure 3 Maximum service temperature (°C)

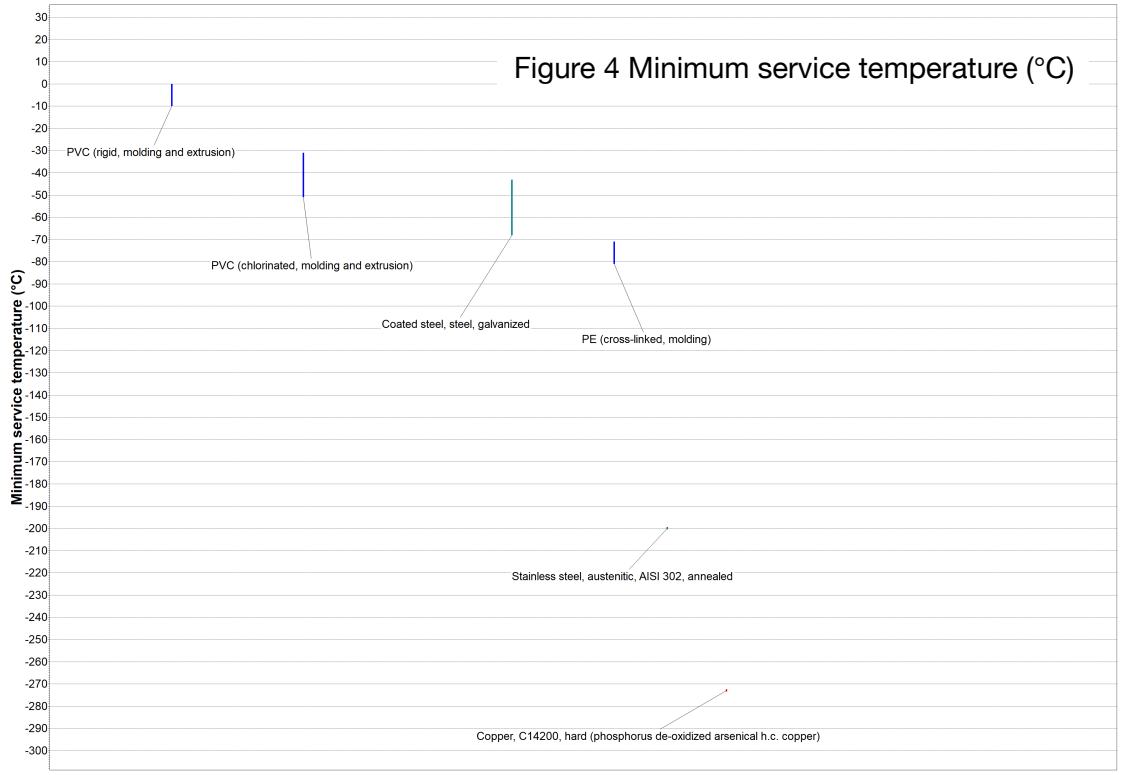

Figure 4 Minimum service temperature (°C)

- **Fresh water**

PEX is applicable to fresh water transport but other 5 types of pipes perform better in carrying fresh water.

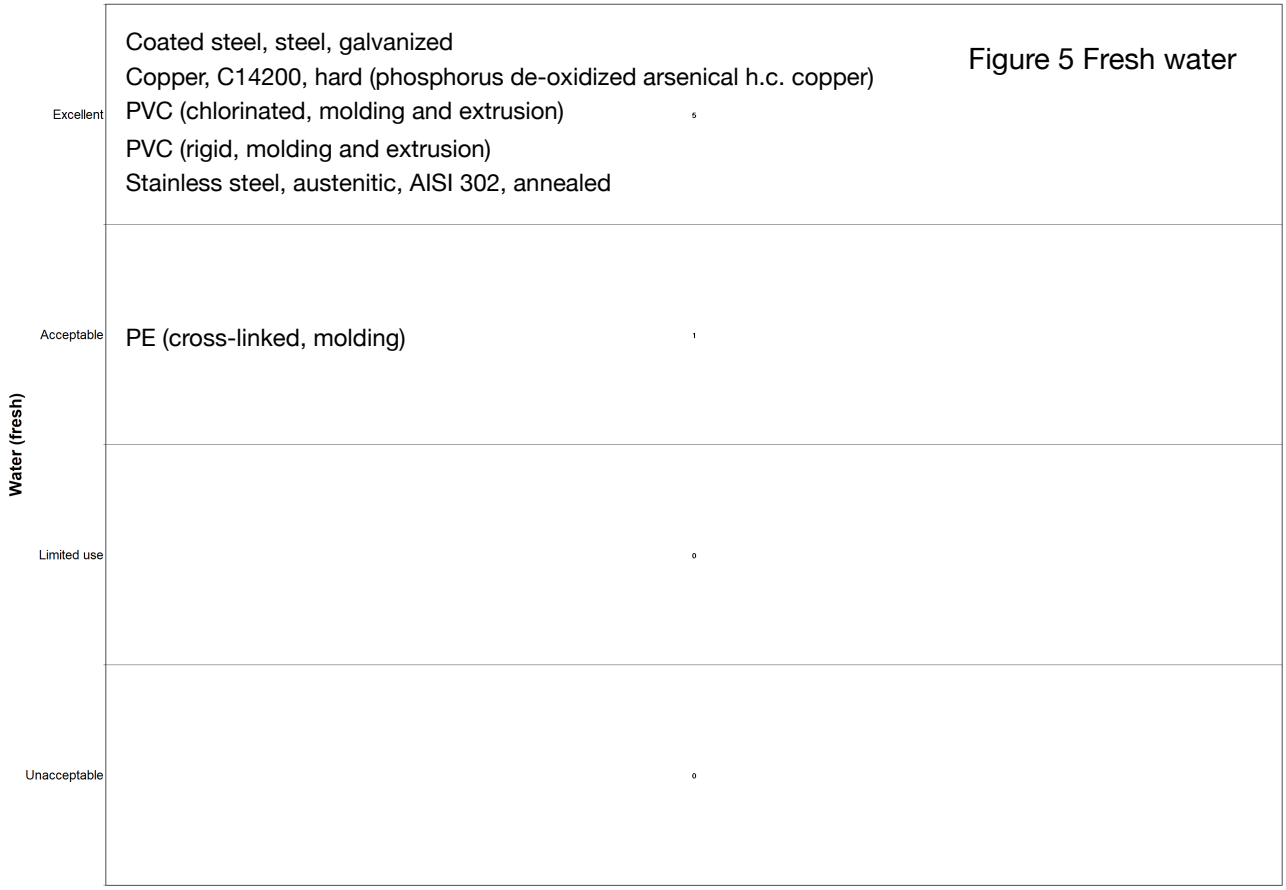

Figure 5 Fresh water

- **Strong acids/alkalis**

Copper and galvanized pipes have low resistance to strong acids. Galvanized pipes also have limited use in a strong alkalis environment.

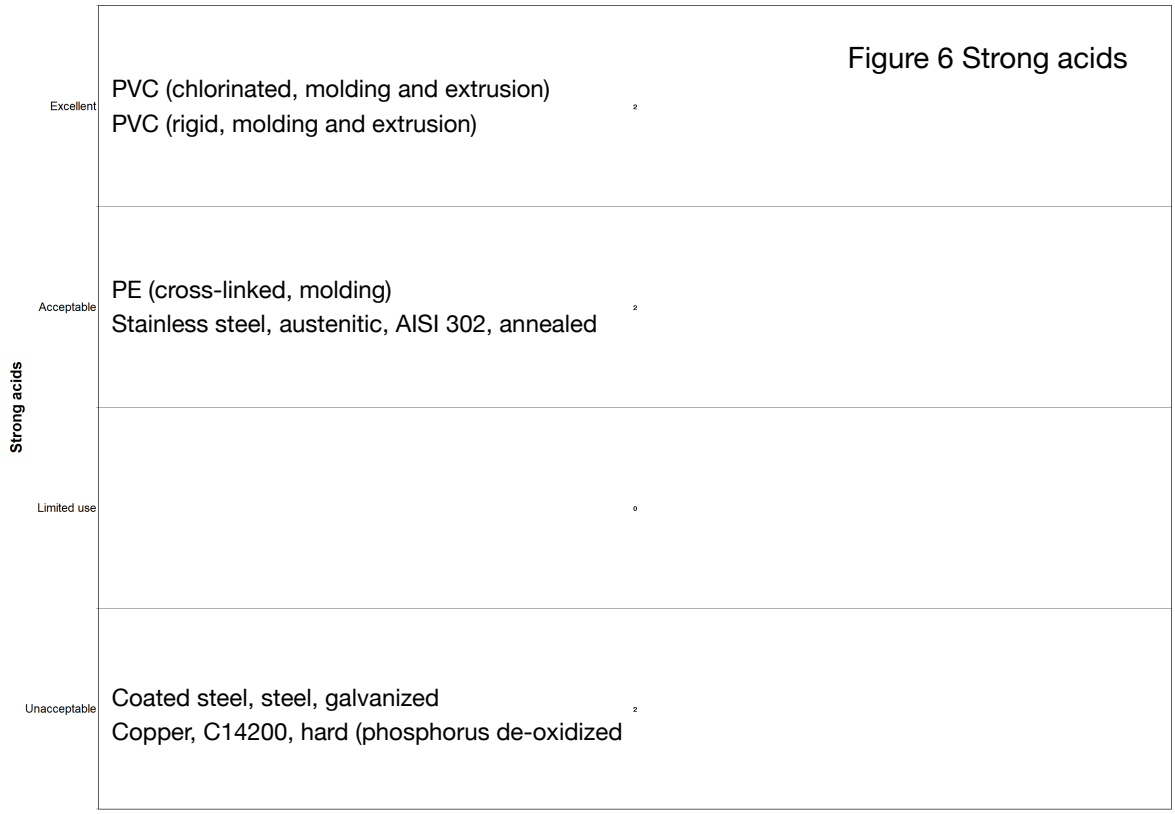

Figure 6 Strong acids

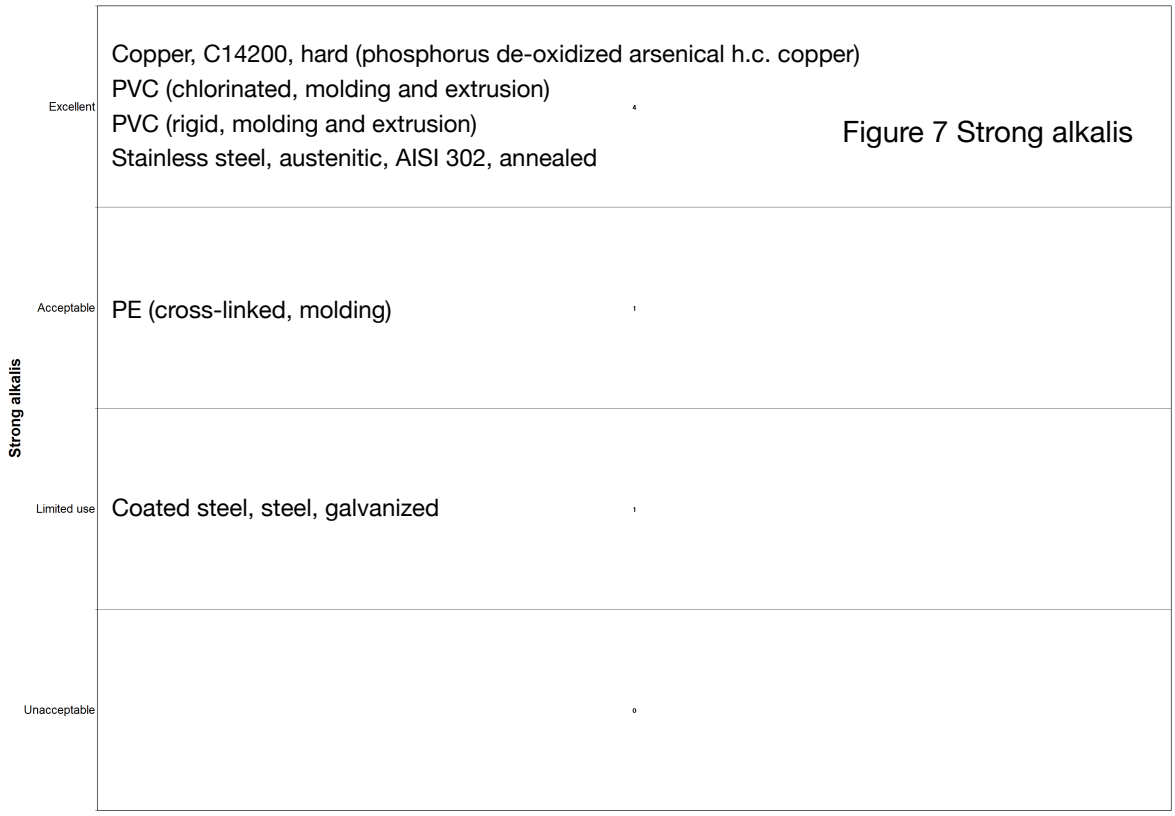

Figure 7 Strong alkalis

- **Weak acids/alkalis**

Normal drinking water generally has a neutral pH of 7.
Galvanized pipes have limited use even in a weak alkalis environment.
All 6 types of pipes are applicable to weak alkalis.

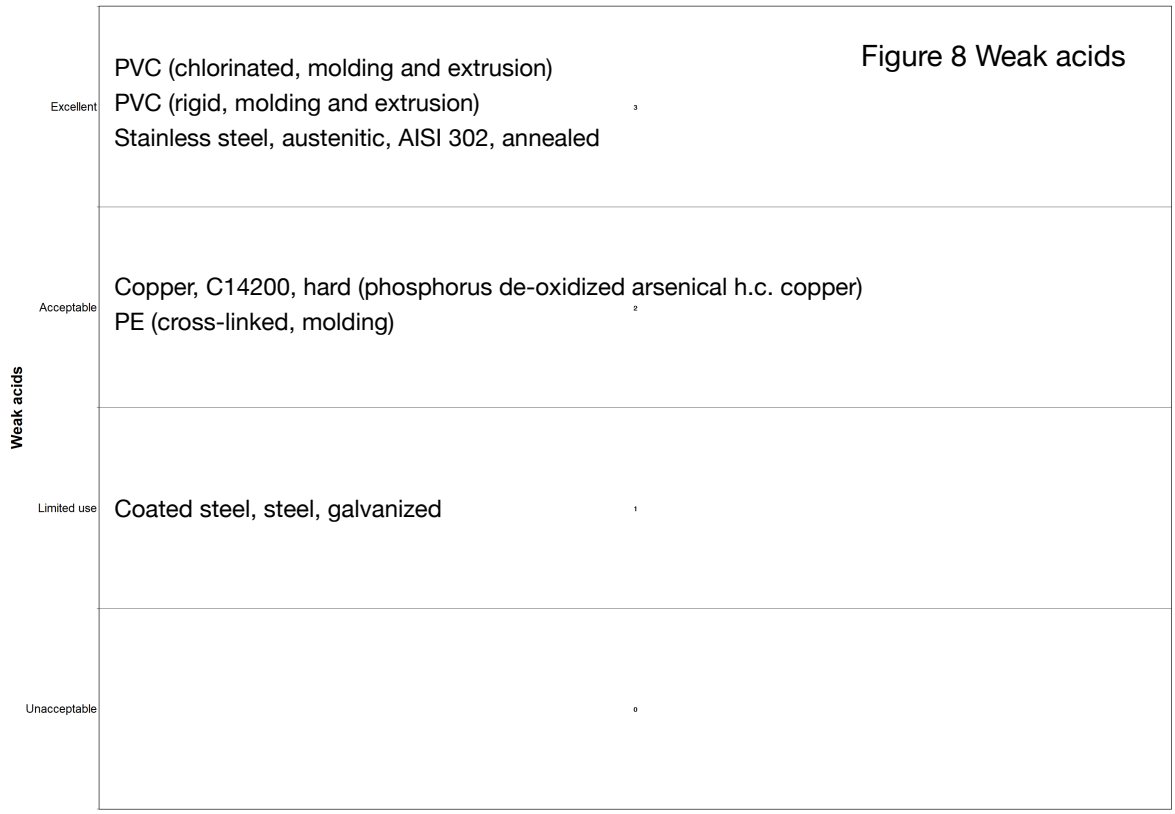

Figure 8 Weak acids

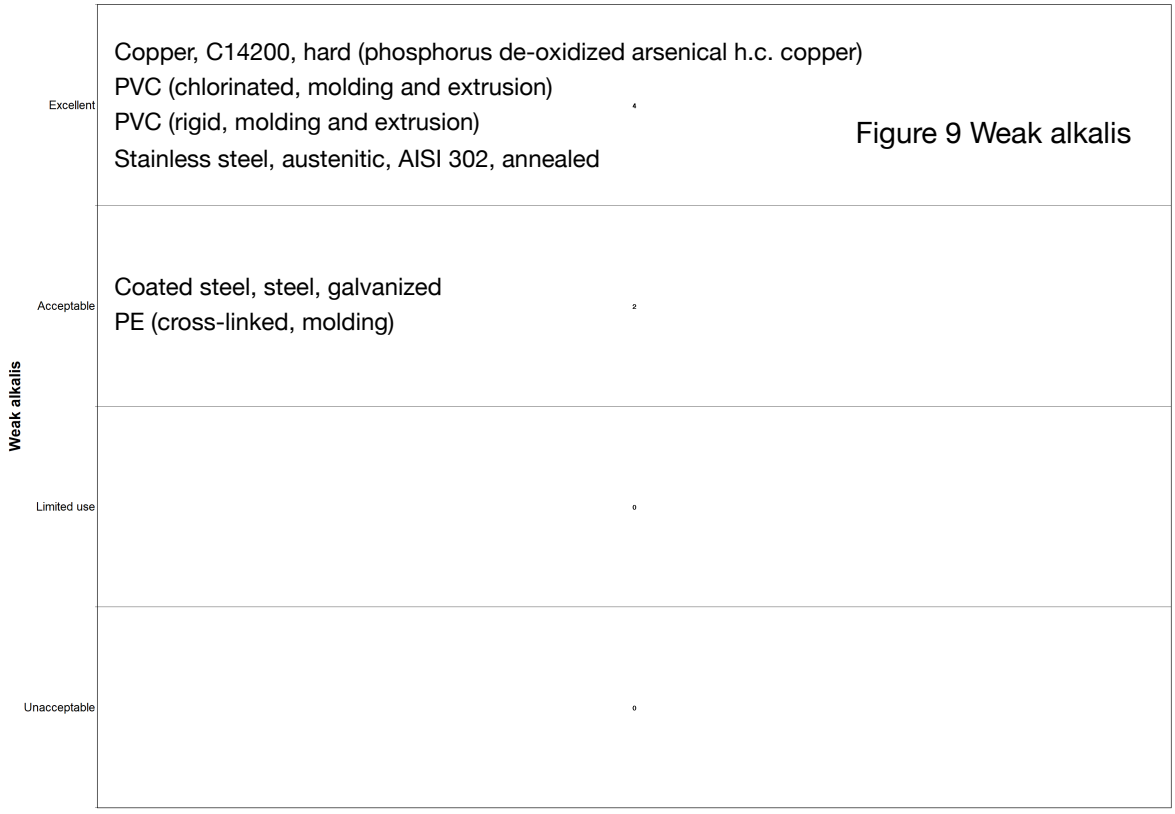

Figure 9 Weak alkalis

- **CO_2 footprint**

From the figures, we can find that metal produces more carbon dioxide during the process of primary production. And PEX has the highest carbon footprint among plastic materials. When it comes to CO_2 footprint of recycling, PEX produces the most carbon dioxide, followed by stainless steel, copper and PVC.

Considering that plastic is much less heavy than metal, and these figures are measured in kilogram, we can see that, in a sense, the metal pipes might have a higher environmental impact than the plastic ones with the same length.

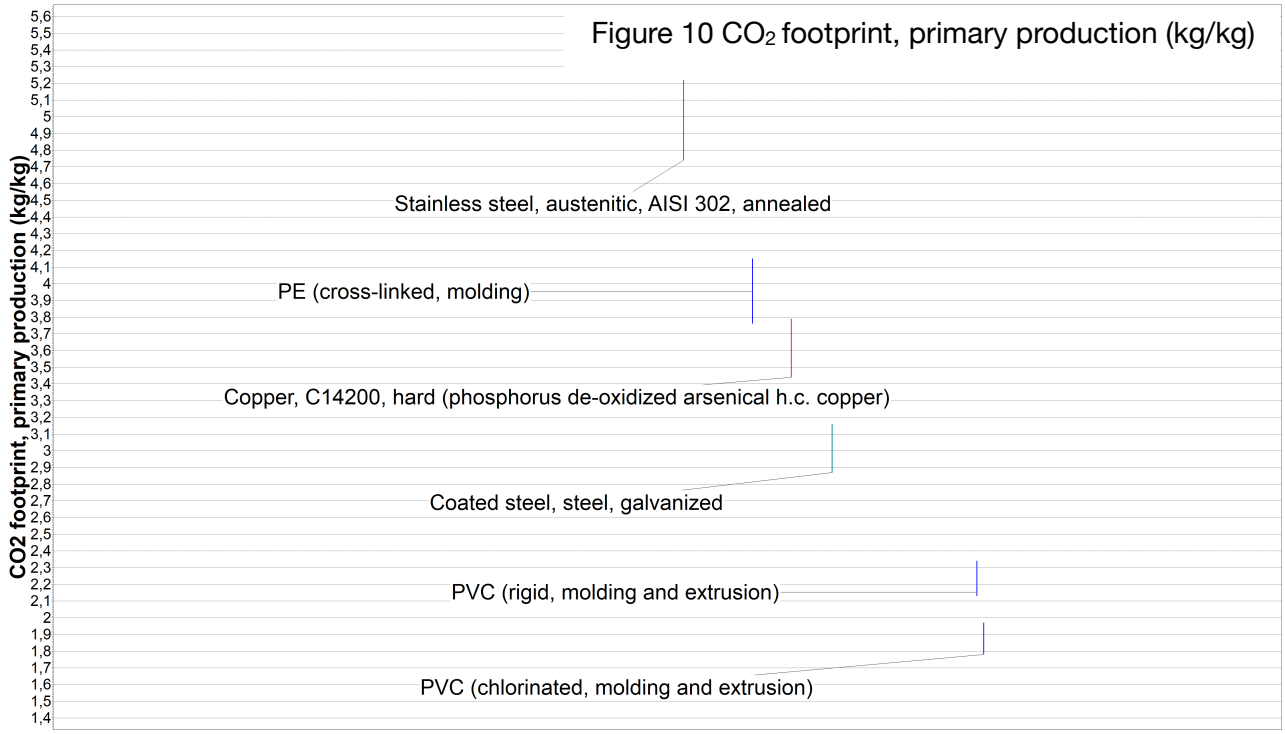

Figure 10 CO_2 footprint, primary production (kg/kg)

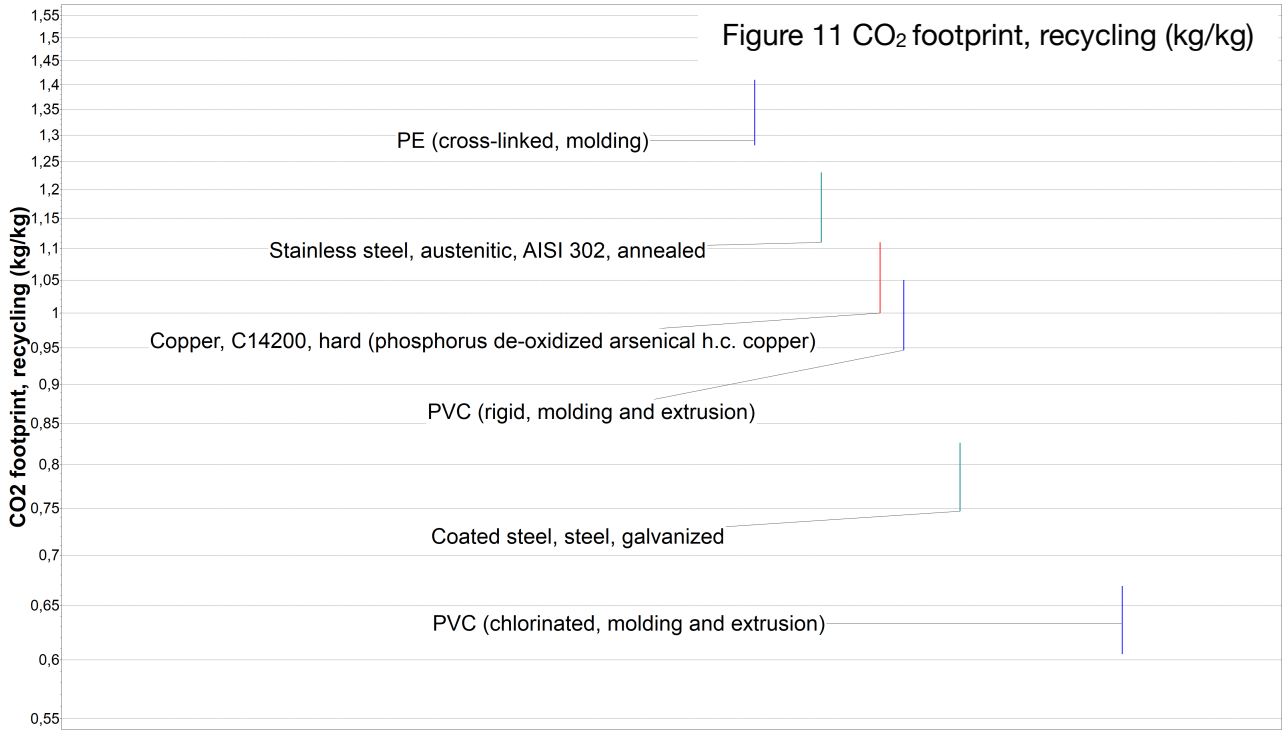

Figure 11 CO_2 footprint, recycling (kg/kg)

Integration

According to the fact-finding step, there are some integrated views of advantages and disadvantages of 6 main drinking water pipe materials. Economic and environmental sustainability of the triple bottom lines would be taken into consideration in this section.

- **Galvanized pipes**

From the fact-finding, it proves that galvanized pipes are easily affected by strong acids and alkalis, and even weak alkalis. As mentioned in the project statement, galvanized steel or iron water pipes were widely used in the 1970s but could be hardly found in today's modern homes. They are more likely to suffer from internal rusting and librate lead in drinking water that is highly harmful to human health.

- **Copper and stainless steel pipes**

Metal pipes have high performance in corrosion resistance and durability. However, copper is the most expensive one among these 6 types of materials with an estimated price between 4000 and 4300 euros per cubic meter. And stainless steel pipes are also very expensive (in some cases they are even more expensive than copper). From the perspective of economic sustainability, they could not be the first choices for ordinary residential potable water supply to a certain degree due to the high prices.

- **PVC pipes**

PVC has these common advantages in plastic pipes, such as resistance to rusting, corrosion and degradation over time.

However, from the analysis in fact-finding section, we can see that PVC can not carry hot water. Furthermore, they would produce toxic substances at high temperature.

According to Cradle to Cradle Material Protocol, PVC is considered to be an ecologically inappropriate material because of its organochlorine content, its use and generation of chronic toxicants in manufacturing (including the known carcinogens vinyl chloride monomer and dioxins), and its generation of dioxins and furans when burned (Rossi, et al., 2006).

- **CPVC pipes**

By integrating extra chlorine, it is safer for drinking water. And CPVC is capable of carrying hot water. However, in term of minimum service temperature, CPVC still has the likelihood of split in a cold environment where water might be frozen. And from the aspect of environmental sustainability, the old CPVC pipes can not be recycled, which might cause a huge environmental impact.

- **PEX pipes**

Besides the common merits of plastic pipes (such as cheaper than metal, less heavy, easy to work with/DIY), PEX is also known for its best flexibility in retrofits. PEX can straight cross a long distance without splicing, as well as freely bend to meet different requirements. And it has high performance in high-temperature environment compared to other plastic materials.

Reflection

For ordinary domestic households (the primary stakeholders), PEX would be the best choice, with advantages of low prices, light weight, flexibility, easy DIY and relatively high firmness. Without considering economic factors, the best choices for family use would be metal pipes, and copper pipes are even better due to the lower carbon dioxide footprint in the processes of production and recycling, compared to stainless steel pipes.

For the secondary stakeholders, pipe makers and their suppliers, the environmental footprint in the production process is a significant index. In my opinion, they need to consider and contribute more to reduce the carbon emission, not only in the materials sourcing, manufacturing, distribution and logistics, but the use phase and the disposal and recycling that would cause carbon footprints as well, in which they might not play the main role yet.

It is very hard to tell the actual situations by comparing the carbon dioxide footprint of the 6 types of materials measured in kilogram due to their diverse densities. To a certain degree, metal pipes might be much heavier and have higher carbon footprint than plastic pipes when they have the same length in use.

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