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Application of risk analysis to improve environmental sustainability of water in construction sites

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Abstract. Water is pivotal for human life. The sustainable development of goods and facilities should account for its preservation in terms of both quantity and quality. In this paper a brief case study on the water consumption and management of construction sites was presented. By means of a methodology developed by the authors, the process, product and service water exploited in building processes have been analysed. The results show that the water-loss is spread in the different phases of the processes involving machinery, materials, work organization and environment. The tool, coupled with a check-list approach, is available for designers and managers in order to lead to a new awareness on the issue and improve the sustainability of construction sites.

Keywords: construction sites, engineering, environmental management, natural resources, sustainability, water.

1 Introduction

Water is crucial for human life and essential for the life cycle of the Earth, the only living environment for mankind. Several approaches to quantify water consumption by diverse activities have been developed [1], [2]. The Water Footprint is one of the indicators that enables water consumption quantification to produce goods or services [3].

Water is subjected to many laws and regulations. However, they do not provide a proper support in quantifying the fair amount of water to be used in a specific human activity so as to avoid unnecessary wastage. The conservation of water in productive processes should be considered as a resource, as this element is a common good to preserve in quality and quantity. The movement towards a sustainable management is fundamental in countries where water resources are already limited or where shortcomings have been forecast due to the ongoing process of climate change. [4], [5].

The main goal of the present paper was to summarize the state of water management and consumption within the construction sites. The research here presented focused to the Italian case. The methodology has already been used by the authors in different environmental and occupational contexts [6], [7]. An extract of the main outcomes was summarised in tabular form.

2 Materials and Methods

In this study, the authors attempted to focus on the presented issue by means of a recently developed matrix-based analysis [8], [9]. Firstly, the production processes are divided into phases, sub-phases and elementary stages. Then, focusing on the last, the used machinery and equipment, the materials (grouped into raw materials, complementary materials, waste and products), the working environment and the organisation of the working activities are outlined. Therefore, an exhaustive analysis of all the different drivers for environmental impacts is implemented: the breakdown structure of the method allows highlighting the link between water use and its root causes.

The types and quality of water used in processes have been classified as follows:

- Product water: it becomes part of construction materials (e.g. steel, cement or glass) [10]. It generally does not produce wastes.
- Process water: includes all the water used in the production processes, which is then discarded as waste after achieving its function. This is difficult to account for during the design phase. Treatment methods should be defined for any site.
- Service water: it is present on the site to guarantee the necessary sanitary facilities for the workers; it exits from the site as civil wastewater.

3 Results

Following the matrix scheme, the use of process, product and service water is showed for the site cases here taken as examples (Tab. 1). This table shows a good correlation between the type of water and the application field where it is needed. This correlation is independent of the site typology. Indeed, many potential improvements should be considered in the process water management, since in this field of application the water resource do not need very high chemical qualities and there are more chances of reuse.

Tab 1. Extract from the water-use table

<table>
<tr><th>Engineering area</th><th>Macro-area</th><th>Project</th><th>Application field</th><th>Water type</th></tr>
<tr><td rowspan="14">Building engineering</td><td rowspan="14">Construction of new build-ing</td><td rowspan="7">Residential</td><td rowspan="2">Machinery</td><td>Process water</td></tr>
<tr><td>Product water</td></tr>
<tr><td rowspan="2">Materials</td><td>Process water</td></tr>
<tr><td>Product water</td></tr>
<tr><td>Work organization</td><td>Service water</td></tr>
<tr><td rowspan="2">Work environment</td><td>Process water</td></tr>
<tr><td>Service water</td></tr>
<tr><td rowspan="7">Non residential</td><td rowspan="2">Machinery</td><td>Process water</td></tr>
<tr><td>Product water</td></tr>
<tr><td rowspan="2">Materials</td><td>Process water</td></tr>
<tr><td>Product water</td></tr>
<tr><td>Work organization</td><td>Service water</td></tr>
<tr><td rowspan="2">Work environment</td><td>Process water</td></tr>
<tr><td>Service water</td></tr>
</table>

Civil engineering	Construction of linear utility	Roads	Machinery	Process water
				Product water
			Materials	Process water
				Product water
			Work organization	Service water
			Work environment	Process water
				Service water
		Railways	Machinery	Process water
				Product water
			Materials	Process water
				Product water
			Work organization	Service water
			Work environment	Process water
				Service water
		Power-lines	Machinery	Process water
				Product water
			Materials	Process water
				Product water
			Work organization	Service water
			Work environment	Process water
				Service water
		Water mains	Machinery	Process water
				Product water
			Materials	Process water
				Product water
			Work organization	Service water
			Work environment	Process water
				Service water
Mining engineering	Underground mining	Soft rock	Machinery	Process water
				Product water
			Materials	Process water
				Product water
			Work organization	Service water
			Work environment	Process water
				Service water
		Hard rock	Machinery	Process water
				Product water
			Materials	Process water
				Product water
			Work organization	Service water
			Work environment	Process water
				Service water

4 Conclusion

The results show that, the three kinds of water present on the site are not strictly connected to the engineering area involved or the project carried out, but mainly to the application field (machinery, materials, work organization and work environment). For example, materials usually require process water and product water.

By knowing the link between water use and its root causes it is possible to design targeted measures to reduce water consumption.

This outcome suggests that a common basic water cycle among construction sites could be identified. This cycle comprises water supplies, methods of purification and re-injection of water into the environment. Multiple alternatives considering the nature of the area in which the construction site operates, the available resources, the used machinery and methods could be settled. The model might pave the way for a renewed regulation in this field for this vital resource. The research activity by the authors is now proceeding with the development of decision-making tools, such as checklists, to be proposed to site designers to create a first point of discussion between the business language and that of environmental safety. This research will be presented in subsequent works.

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