

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

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Application of risk analysis to improve environmental sustainability of water in construction sites / Fornasari, Francesca; Bo, Matteo; Formisano, Francesco; Pognant, Federica; Clerico, Marina. - ELETTRONICO. - (2021), pp. 487-491. ( 2nd Euro-Mediterranean Conference for Environmental Integration (EMCEI-2) Sousse, Tunisia 10-13 October, 2019) [10.1007/978-3-030-51210-1\_77].

*Availability:*

This version is available at: 11583/2906634 since: 2021-06-14T17:43:07Z

*Publisher:*

Springer

*Published*

DOI:10.1007/978-3-030-51210-1\_77

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

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7           **Abstract.** Water is pivotal for human life. The sustainable development of  
8           goods and facilities should account for its preservation in terms of both quantity  
9           and quality. In this paper a brief case study on the water consumption and man-  
10          agement of construction sites was presented. By means of a methodology de-  
11          veloped by the authors, the process, product and service water exploited in  
12          building processes have been analysed. The results show that the water-loss is  
13          spread in the different phases of the processes involving machinery, materials,  
14          work organization and environment. The tool, coupled with a check-list ap-  
15          proach, is available for designers and managers in order to lead to a new aware-  
16          ness on the issue and improve the sustainability of construction sites.

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

19          **1 Introduction**

20          Water is crucial for human life and essential for the life cycle of the Earth, the only  
21          living environment for mankind. Several approaches to quantify water consumption  
22          by diverse activities have been developed [1], [2]. The Water Footprint is one of the  
23          indicators that enables water consumption quantification to produce goods or services  
24          [3].

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

32          The main goal of the present paper was to summarize the state of water manage-  
33          ment and consumption within the construction sites. The research here presented fo-  
34          cused to the Italian case. The methodology has already been used by the authors in  
35          different environmental and occupational contexts [6], [7]. An extract of the main  
36          outcomes was summarised in tabular form.

## 37 2 Materials and Methods

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

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

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

## 55 3 Results

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

63  
64

*Tab 1. Extract from the water-use table*

Engineering area	Macro-area	Project	Application field	Water type
Building engineering	Construction of new building	Residential	Machinery	Process water
				Product water
			Materials	Process water
				Product water
			Work organization	Service water
			Work environment	Process water
		Service water		
		Non residential	Machinery	Process water
				Product water
			Materials	Process water
				Product water
			Work organization	Service water
Work environment	Process water			
	Service water			

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		

#### 65 4 Conclusion

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

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

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

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