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Predicting on-site environmental impacts of municipal engineering works

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ABSTRACT

The research findings fill a gap in the body of knowledge by presenting an effective way to evaluate the significance of on-site environmental impacts of municipal engineering works prior to the construction stage. First, 42 on-site environmental impacts of municipal engineering works were identified by means of a process-oriented approach. Then, 46 indicators and their corresponding significance limits were determined on the basis of a statistical analysis of 25 new-build and remodelling municipal engineering projects. In order to ensure the objectivity of the assessment process, direct and indirect indicators were always based on quantitative data from the municipal engineering project documents. Finally, two case studies were analysed and found to illustrate the practical use of the proposed model. The model highlights the significant environmental impacts of a particular municipal engineering project prior to the construction stage. Consequently, preventive actions can be planned and implemented during on-site activities. The results of the model also allow a comparison of proposed municipal engineering projects and alternatives with respect to the overall on-site environmental impact and the absolute importance of a particular environmental aspect. These findings are useful within the framework of the environmental impact assessment process, as they help to improve the identification and evaluation of on-site environmental aspects of municipal engineering works. The findings may also be of use to construction companies that are willing to implement an environmental management system or simply wish to improve on-site environmental performance in municipal engineering projects.

1. Introduction

According to the United Nations Human Settlements Programme (2009), the major urban challenges of the twenty-first century include the rapid growth of small- and medium-sized towns. Between 2007 and 2025, the annual urban population increase in developing regions is expected to be 53 million (or 2.27%) (United Nations Human Settlements Programme, 2009). The actual rate could be even greater, as in China alone the number of people who move annually from rural to urban areas has been estimated at approximately 21.1 million (He et al., 2013). In addition, the annual urban population increase in developed regions is expected to be 3 million (or 0.49%) between 2007 and 2025 (United Nations Human Settlements Programme, 2009). This will obviously require a great amount of municipal engineering works. Moreover, cities in developed countries have to cope with an increasingly ageing infrastructure. This problem is compounded by the fact that post-industrial European cities are characterized by dispersed urbanization (Riera and Rey, 2013). Since municipal engineering projects are concerned with public infrastructure and services provided by local government, they play a key role in improving the community's health and quality of life. Municipal engineering projects include the design, planning, construction and maintenance of streets, pavements, bicycle paths, public parks and related urban public facilities (street lighting, as well as street furniture and fixtures such as benches, bus shelters, litter bins, traffic control devices, playground equipment and road signs). The term "municipal engineering projects" also covers sanitary and storm sewer systems and municipal solid waste management and disposal facilities. Civil infrastructure (conduits and access chambers) related to utility services (water supply, electrical distribution and telecommunication networks) are also included within this term.

Although municipal engineering works have made significant contributions to sustainable development in the past, particularly in terms of social aspects, their on-site environmental impacts have often been overlooked. In most cases, municipal engineering projects are not subject to environmental impact assessment (EIA); a process by which the environmental effects of a proposed project during the construction, operation and dismantling phases are assessed at an early stage. Industrial estate development projects and urban development projects are listed in Annex II of the EIA directive (European Union, 2011), and thus they are subject to a screening process. In this case, Member States determine the need for an EIA on a case-by-case basis or according to pre-defined thresholds or criteria (size, location, etc.). Although the

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Table 1
Evaluation of the environmental impacts of municipal engineering works.

Environmental aspect		Indicator[a]	SV[b] = 0	SV = 1	SV = 3	SV = 5	CO[c] = 1	CO = 3	CO = 5
Atmospheric emissions									
AE-1	Generation of greenhouse gas emissions due to construction machinery and vehicle movements in on-site municipal engineering works	Running time of on-site construction machinery and vehicles [h]	P[a] = 0.00	0.00 < P ≤ 575.04	575.04 ≤ P < 7083.00	P ≥ 7083.00	–	–	All cases
		Volume of excavated/ supplied material [m^3]	P = 0.00	0.00 < P ≤ 800.70	800.70 ≤ P < 33,508.19	P ≥ 33,508.19			
AE-2	Generation of VOCs and CFCs due to asphalt mixing in on-site municipal engineering activities	Area paved with asphalt [m^2]	P = 0.00	0.00 < P ≤ 92.66	92.66 ≤ P < 8171.42	P ≥ 8171.42			
AE-3	Generation of VOCs and CFCs during painting, treatment or finishing in on-site municipal engineering activities	On-site surface painted with non-ecofriendly or waterproofing paints [m^2]	P = 0.00	0.00 < P ≤ 41.00	41.00 ≤ P < 2123.06	P ≥ 2123.06			
Water alteration									
WA-1	Dumping of sanitary water resulting from on-site sanitary conveniences in municipal engineering works	Average number of workers per day [number of workers]	P = 0.00	0.00 < P ≤ 6.37	6.37 ≤ P < 16.54	P ≥ 16.54	Connection to sewage system	Dumping in septic tank and/or existence of previous treatment	Direct dumping to the natural or urban environment
WA-2	Dumping of water resulting from the execution of retaining walls in on-site municipal engineering works	Use of thixotropic fluid	No use of thixotropic fluid	–	Use of thixotropic fluid	–	Existence of an in situ waterproof settling basin or watertight tank	Connection to sewage system, dumping in septic tank and/or existence of previous treatment	Direct dumping to the natural or urban environment
WA-3	Dumping of water from cleaning painting tools in on-site municipal engineering works	On-site surface painted with non-ecofriendly paints [m^2]	P = 0.00	0.00 < P ≤ 33.57	33.57 ≤ P < 1167.83	P ≥ 1167.83			
WA-4	Dumping of water from cleaning concrete chutes or dumping of other basic fluids in on-site municipal engineering works	Volume of in-situ concrete [m^3]	P = 0.00	0.00 < P ≤ 252.24	252.24 ≤ P < 3835.39	P ≥ 3835.39			
WA-5	Dumping of dangerous liquids in on-site municipal engineering works	On-site surface painted with non-ecofriendly or waterproofing paints [m^2]	P = 0.00	0.00 < P ≤ 41.00	41.00 ≤ P < 2123.06	P ≥ 2123.06			
		Use of varnishes or oils	No use of varnishes or oils	–	Use of varnishes or oils	–			
Waste generation									
WG-1	Generation of inert waste during on-site municipal engineering works involving demolitions, earthworks, foundations and paving	Volume of excavated material ending up in landfill sites [m^3]	P = 0.00	0.00 < P ≤ 129.40	129.40 ≤ P < 11,801.64	P ≥ 11,801.64	In situ reuse or selective waste collection and delivery to an authorized manager for future reuse or recycling	Selective waste collection and delivery to an authorized manager with unknown final waste destination	Non-selective waste collection and delivery to an authorized manager or on-site waste management unawareness
		Volume of in-situ concrete [m^3]	P = 0.00	0.00 < P ≤ 252.24	252.24 ≤ P < 3835.39	P ≥ 3835.39			
		Paved area with prefabricated stones [m^2]	P = 0.00	0.00 < P ≤ 939.84	939.84 ≤ P < 9882.38	P ≥ 9882.38			
		Length of kerbs and gutters [m]	P = 0.00	0.00 < P ≤ 112.25	112.25 ≤ P < 3680.22	P ≥ 3680.22			
WG-2	Generation of non-special waste resulting from packaging and surplus material in on-site municipal engineering works	Weight of on-site material [kg].	P = 0.00	0.00 < P ≤ 950,618.87	950,618.87 ≤ P < 22,010,443.44	P ≥ 22,010,443.44			