Environmental life cycle assessment of the innovative ejectors plant technology for sediment management in harbours

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Introduction: Preservation of a good navigability is a challenging issue, since port and harbour access and waterways are often hampered, as the vast majority of 10,000s of ports and harbours worldwide suffer from sedimentation. Traditionally, the sediment that causes the problem is excavated, removed and relocated through maintenance dredging. Nevertheless, dredging is not effective in keeping navigability over the time and also has considerable environmental impacts, since dredging operations can: i) destroy or greatly modify underwater habitats and resident flora and fauna, ii) resuspend sediments and contaminants already present in the seabed, thus increasing the Suspended Solid Concentration (SSC) in the water column with negative effects for the ecosystem, iii) impact locally on greenhouse gas (GHG), pollutants and noise emissions, iv) generate a waste to be disposed, i.e. the dredged material. The "*ejectors plant*" technology has been developed as a sustainable alternative to maintenance dredging and has been tested in the first demo application in the Marina of Cervia (Italy) [1]. The demo plant operated from June 2019 to September 2020 with the final aim of keeping water depth at the Marina entrance over 2.5 meters.

Methods: An environmental life cycle assessment (LCA) has been performed accordingly to with ISO 14040/14044 standards to evaluate the sustainability of Cervia ejectors demo plant, which is the functional unit of the analysis. Due to the goal of the paper, the choice of system boundaries considered only emissions related to raw materials processing and plant operation phases. The other phases of plant construction (components manufacturing, transport and assembly) as well as decommissioning phase was not included. The emissions comprehend various pollutants (CO_2, NO_x, particulate matter, SO_x, ...) and specific emission factors for each pollutant were found in the following different official publications [2-5]. ReCiPe2016 methodology has been applied as characterization model for the calculation of the impacts at a midpoint and endpoint levels.

Results: Table 1 summarizes the impacts on CO_2 emission of the ejectors plant construction and operation referred to the functional unit and by considering three different scenarios (Ss), that are i) current scenario (i.e. measured energy consumption and realistic emission impact), ii) optimized scenario (i.e. optimized energy consumption and realistic emission impact), and iii) best scenario (i.e. optimized energy consumption and low emission impact).

Tab. 1: CO_2 emission (in ton) over 20 years.

Boundary	Source	S1	S2	S3
Construction	Material	58	29	29
Operation	Energy	3498	970	65
	Material	5	3	3

Table 2 shows the results of midpoint characterization factor for assessing climate change impacts through Global Warming Potential (GWP).

Tab. 2: Midpoint characterization.

Midpoint parameter	S1	S2	S3
GWP100 (ton CO_2 to air)	3561	1002	96

Discussion: Table 1 confirms that the plant operation produces much higher CO_2 emissions than plant construction. Nevertheless, construction scenario is much relevant in terms of other impacts (not shown in this short abstract). Moreover, while in S1 and S2 the impact on CO_2 emission of ejectors plant operation is, respectively, 98% and 97%, in S3 the weight of operation reduces to 67%. Therefore, it is anyway relevant to work on the assessment of ejectors plant construction phase impact to reduce the related impacts moving towards more sustainable solution. The minimum impact is achieved in S3, in which the power consumption of the plant is hypothesized to be satisfied only by renewable energy. This is a relevant aspect since the electrification of sediment management through the adoption of the ejectors plant technology can be beneficial in terms of air emissions reduction only if the power source is renewable (generated locally, for example by photovoltaic panels, wind-turbines and/or wave energy converter, or purchased by the grid).

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References: [1] Pellegrini et al. (2020) *J Soils Sediments* **20**:6. [2] IPCC (2013) [3] EMEP/EEA (2019) [4] https://www.carbonfootprint.com (2020) [5] GSE (2018)