SCACR2019 – International Short Course/Conference on Applied Coastal Research
Engineering, Geology, Ecology & Management
9th – 11th September 2019 – Bari, Italy

THE SEABED MAINTENANCE THROUGH A JET-PUMP DEVICE: THE CASE STUDY OF RODI GARGANICO (SOUTH ITALY)

C. Saccani[1], L. Damiani[2],A. Bianchini[3], M. Pellegrini[3], A. Guzzini[1], R Archetti[4], A. Saponieri[2], M.F. Bruno[2], B. Nobile[2]

Paper topic: Coastal engineering, oceanography, geology & ecology

1. Abstract

Although the importance, sediment siltation represents a very critical barrier for the operability of the harbor of Rodi Garganico (Italy). Due to negative economic impact, in fact, traditional dredging results an unviable solution. For this purpose, an innovative solution, called the "ejector", is proposed for the specific case. Based on several positive applications in Italy, in fact, many positive benefits are expected in addition to the maintenance of the basin depth. Therefore, after a brief outlook of the current conditions in the harbor of Rodi Garaganico, the paper gives some technical specifications regarding the technology and the preliminary considerations that were following for the plant design.

2. Introduction

In Italy the management of sediments within harbors represents a difficult problem to solve which often compromises the functionality and financial sustainability of ports. Even in presence of unpolluted sediments which would be suitable for nourishment interventions (Mali et al., 2017), the high dredging costs as well as the procedures aiming at defining the appropriate destination site make this practice particularly complex. It must also be considered that the accumulation of sediments in harbor areas due to the alteration of the natural coastal dynamics also affects water quality, requiring careful and expensive management actions (Malcangio et al., 2017). Accordingly, the seabed maintenance of harbor basins plays a relevant role to guarantee their functionality, to restore the natural regime of long-shore transport and to avoid onerous protective interventions (Saponieri et al., 2018). In addition to sediments management, coastal erosion has also to be managed by local governments to minimize economic and social damages to local economies (Zhang et al., 2014). As reported by (ISPRA, 2008), in fact, erosion is responsible for significant changes in Italian coasts even if similar conditions are found also in other countries. For example, almost the 20% of European coasts, i.e. 20.000 km, is affected by serious erosion (Eurosion project, 2004). Strategies are therefore required by the in-charge Authorities to protect the 2300 km of Italian coasts as counted by national reports.

Although several technical strategies were developed through the years to counteract both sediments accumulation and coastal erosion (de Jonge and Neal, 2018; Gracia et al., 2018; van Rijn, 2011; Williams, 2018; Batuca and Jordaan, 2000), many doubts are still present about their environmental, economic and social consequences (Bianchini et al., 2019). Therefore, considering these factors as an essential target, an innovative solution called the "ejector" was designed, experimentally tested and successfully operated during on-field tests (Bianchini et al, 2013; Bianchini et al., 2014; Pellegrini & Saccani, 2017).

Among the Italian coasts affected by costal erosion and sediments management issues, the Apulian

[1]Department of Industrial Engineering (DIN) – University of Bologna, Viale del Risorgimento 2, - 40136 Bologna, Italy. alessandro.guzzini2@unibo.it, cesare.saccani@unibo.it
[2]DICATECh, Technical University of Bari, via Edoardo Orabona 4, - 70125, Bari, Italy. leonardo.damiani@poliba.it, alessandra.saponieri@poliba.it, mariafrancesca.bruno@poliba.it, biagio.nobile@poliba.it
[3]Department of Industrial Engineering (DIN) – University of Bologna, Via Fontanelle 40, - 47121 Forlì, Italy. augusto.bianchini@unibo.it, marco.pellegrini3@unibo.it
[4]Department of Civil, Environmental, Chemical and Materials Engineering (DICAM) – University of Bologna, Viale Risorgimento, 2 - 40136 Bologna, Italy. renata.archetti@unibo.it

coasts situation were often investigated by several Authors (Bruno et al., 2019). In particular, a critical situation was assessed at Rodi Garganico where an alteration of the natural sediments transport regime occurred resulting in a very negative impact to local economy. Despite the harbor of Rodi Garganico needs preliminary dredging operations in order to restore the adequate depths and hand back the functionality of the basin, it is currently under study the design of a pilot system of ejectors, in order to verify its practicability and efficacy for the further maintenance of the port

For this reason, the paper aims i) to describe the existing situation in the harbor at Rodi Garganico, ii) to illustrate the innovative solution, i.e. the "ejector", as possible countermeasure and iii) to explain the preliminary decisions taken for the design, realization and operation of the plant.

3. The harbor at Rodi Garganico

The area under investigation, i.e., the harbor of Rodi Garganico, which is located in the northern part of Apulia region, South Italy (Figure 1). As consequence of the completion of the harbor at Rodi Garganico in 2009, an alteration of the sediments transport regime occurred resulting in the continuous silting of the harbor entry. Consequently, negative consequences verify on the overall planning of coastal territories. In particular, the breakwater interacts with the long-shore transport with a prevalent W-E direction, inducing the movement of sediments towards high-depths areas (outside the active zone) and the erosion of the east coast. An exception can be observed along the beach immediately behind the port, which is fed by the diffractive effects generated at the head of the breakwater, which are also responsible for the continuous silting of the harbor entrance.

Figure 1: Skecth of ejector system for bed mainainance within the harbour of Rodi Garganico (Apulia region, South Italy).

During the few years of port operation, the area has been yearly dredged by the concessionaire company to allow the access of boats and the mooring of the ferry services to the Tremiti Islands. However, the unsustainable costsy of dredging operations has led to the renunciation of the concession of the port, which has returned to full availability of the State Property under the regional jurisdiction.

4. The ejector technology

Based on the Venturi's effect, the ejector technology (figure 2) is based on the transfer of momentum from a high velocity primary jet flow to a secondary flow that convey away the mixture of sand and seawater, i.e. the slurry. An increase of dynamic pressure occurs along the initial convergent nozzle ensuring the required capacity to suck the mixture of seawater and sediments, suspended by the pressurized jets from the circumferential nozzles. The resultant jet flow finally moves through a second convergent section that ensures the required velocity, i.e. the prevalence, for sand convey.

The continuous plant operation ensures the removal of water-sediment mixture from the surrounding environment within a defined radius. The radius is direct function of friction angle of sand or sludge that has to be moved. Therefore, installing several ejectors in the area of interest, it is possible to create a grid that avoid the accumulation of sediments that are naturally transported in its area of influence. The water-sand mixture is finally moved away to the desired location through a plastic flexible pipe. For the purpose, only few auxiliaries like submersible borehole pumps, mechanical filters and instrumentation are installed in order to respectively supply pressurized water, to avoid the inlet of marine particles and to control the plant.

Figure 2: The ejector technology (Bianchni et al., 2014): 3D design (left) and laboratory tests (right).

Several benefits are clearly recognized. First of all, working with sediments that naturally come to a certain area, the plant does not add or remove the sediment from the area as it results from a neutral mass balance. This condition implies that it cannot be considered a dredging activity and so, in accordance to the Italian normative, no authorization is required. Secondly, no barrier against navigation is expected during the 24/7 operation. Lastly, no moving parts and no electrical cables are present in the core of the technology minimizing maintenance activities and so the operative costs.

To validate these results, several plants were operated and monitored during the years. The first experimental plant was realized and tested in the harbour of Riccione (Italy) in 2005 (Amati and Saccani, 2005). In Riccione case (figure 3), 15 ejectors were designed to cover the 65 meters of the inlet harbour channel aiming to maintain a constant depth (over 3 meters) in the middle of the channel.

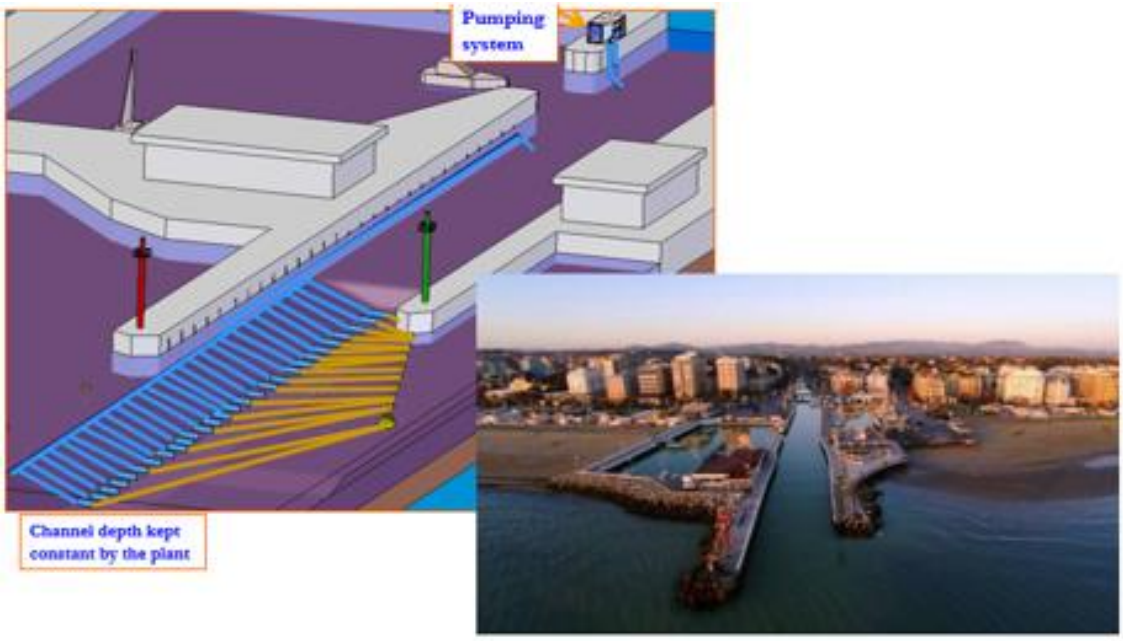

Figure 3: The installation at the Riccione harbor. In the left a schematic representation of the plant is proposed.

In 2012, a second plant was designed and installed at the dock inlet of Portoverde Marina (Italy), figure 4. A fully automated and remotely accessible plant was realized ensuring the recognition of critical sea weather (Bianchini et al., 2014) and of delivery flow conditions (Pellegrini and Saccani, 2017) through dedicated sensors allowing primary flow rate control to the ejectors.

Figure 4: The installation in the harbor at Portoverde in 2012. In the left a schematic representation of the plant is proposed

In addition to these plants, one more plant was realized in July 2019 by Trevi SpA in Cervia (Italy) thanks to the LIFE Programme funding ensuring the evaluation of technical performances and real environmental as well as social outcomes (figure 5).

Figure 5: The installation in the harbor of the municipality of Cervia. In particular, a detail of the two autopurging disk filters within the cabin is shown.

5. The installation in the harbor of Rodi Garganico

Justified by the very positive results obtained, the ejector technology was considered to solve the siltation issue occurring in the harbor of Rodi Garganico. However, before to proceed many technical parameters were required, being the design very sensitive to the specific local working conditions such as, for example, the type of sediments to be transported.

As part of the preliminary numerical investigations for system design, multibeam surveys were underway for the definition of the seabed in front of the port. The wave climate was derived from buoy-measured data in Tremiti Island (Bruno and Petrillo, 2008).

From preliminary considerations, two independent modules supplied by two independent submersible pumps consisting of 3 ejectors were proposed for the specific case. Regarding the position, the ejectors were evaluated at the inlet of the harbor as shown in Figure 6. Since, the technical characteristics of the system do not allow the realization of very long pipes, it was decided to release sediments immediately outside the entrance ensuring also a possible countermeasure to the erosive force against the coast.

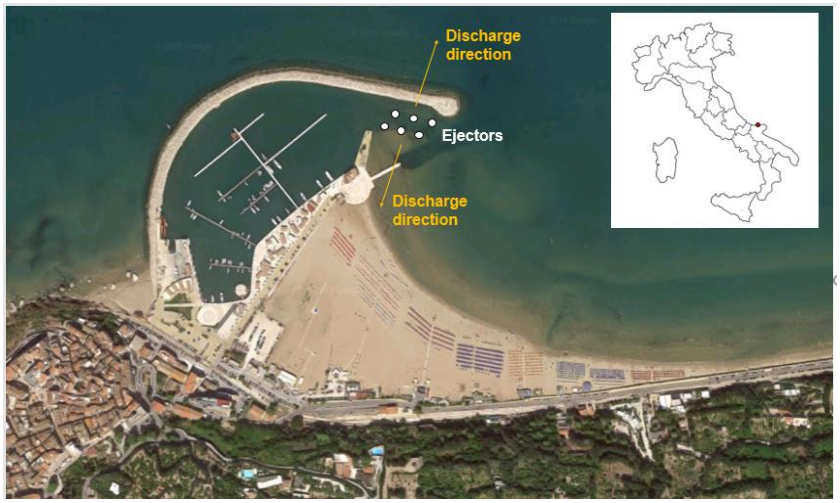

Figure 6: The proposed position of the ejectors in the Rodi Garganico harbor.

To assess the real performance of the plant, a widespread monitoring campaign after the installation of the first module, aimed at evaluating the effectiveness of the plant, will be

performed. In particular, the quantity of sediments removed from the harbor entry and the management costs will be quantified.

6. Conclusions

Innovative strategies are required as soon as possible to counteract sediment accumulation and erosion along to Italian coastal areas. In fact, even if traditional solutions are in many cases able to mitigate these problems, their application is limited due to economic reasons. This situation is especially found in small marinas or in that areas where the functionality of the basins is the condition "*sine qua non*" for the survival of the local economy. Because of the harbor of Rodi Garganico suffers of similar problems, positive results are estimated from the operation of the innovative "ejector" technology. In fact, due to the positive experience assessed during previous field applications, an improved outcome should be reached respect to existing condition. However, to validate technical and economic estimation, a monitoring action is required and so planned for the entire duration of the project.

References

Amati, G., Saccani, C., 2005. Experimental plant for sand removal from harbour areas seabed. *Proceedings of the XXXII National Conference on Italian Plant Engineering*, Rimini, Italy

Batuca, D.G., Jordaan, J.M., 2000. Silting and Desilting of Reservoirs. Balkema Publishers. Rotterdam.

Bianchini, A., Pellegrini, M., Preda, G., Saccani, C. Vanni, D., 2013. Integrated technologies for sediment treatment. Extended abstract. *Environmental Engineering and Management Journal*, 12(S11), pp. 253-256

Bianchini, A., Pellegrini, M., Saccani, C., 2014. Zero environmental impact plant for seabed maintenance, 4th International Symposium on Sediment Management (I2SM).

Bianchini, A., Cento, F., Guzzini, A., Pellegrini, M., Saccani, C., 2019. Sediment management in coastal infrastructures: Techno-economic and environmental impact assessment of alternative technologies to dredging. *Jornal of Environmental Management*, 248, pp. 1-17

Bruno M. F., Petrillo A. F., 2008. Analysis on meteomarine climate at Tremiti islands. *Coastlab 2008*, Bari, Italy.

Bruno M.F., Molfetta M.G., Pratola L., Mossa M., Nutricato R., Morea A., Nitti D.O., Chiaradia M.T., 2019. A Combined Approach of Field Data and Earth Observation for Coastal Risk Assessment. *Sensors*, 19, pp. 1399-1418.

de Jonge, V.N., Neal, W., 2018. How to make Integrated Coastal Erosion Management a reality. *Ocean & Coastal Management*, 156, pp. 290-299.

Eurosion project, 2004. Living with coastal erosion in Europe: Sediment and Space for Sustainability.

Gracia, A., Rangel-Buitrago, N., Oakley, J.A., Williams, A.T., 2018. Use of ecosystems in coastal erosion management. *Ocean & Coastal Management*, 156, 277-289.

ISPRA, 2008. Coastal areas. *Annuario 2008*, pp. 257-292.

Malcangio, D., Melena, A., Damiani, L., Mali, M., Saponieri, A., 2017. Numerical study of water quality improvement in a port through a forced mixing system. *WIT Transactions on Ecology and the Environment*, 220, pp. 69-80.

Mali, M., Dell'Anna, M. M., Mastrorilli, P., Damiani, L., & Piccinni, A. F., 2017. Assessment and source identification of pollution risk for touristic ports: Heavy metals and polycyclic aromatic hydrocarbons in sediments of 4 marinas of the Apulia region (Italy). *Marine pollution bulletin*, 114(2), pp. 768-777.

Pellegrini, M., Saccani, C., 2017. Laboratory and field tests on photo-electric probes and ultrasonic Doppler flow switch for remote control of turbidity and flowrate of a water-sand mixture flow. *Journal of Physics: Conference Series*, 882, 012008.

van Rijn, L.C., 2011. Coastal erosion and control. *Ocean & Coastal Management*, 54, pp. 867-887.

Saponieri, A., Valentini, N., Di Risio, M., Pasquali, D., & Damiani, L. (2018). Laboratory Investigation on the Evolution of a Sandy Beach Nourishment Protected by a Mixed Soft–Hard System. *Water*, 10(9), 1171.

Zhang, K., Leatherman, S.P., Douglas, B.C., 2014. Global Warming and Coastal Erosion. *Climatic Change*, 64, pp. 41-58

Williams, A.T., 2018. The management of coastal erosion. *Ocean & Coastal Managagement*, 156, pp. 4-20.