Urban run-off management in a Greek coastal city: Citizens' awareness, attitudes and proposed solutions

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Abstract

The storm water quality of the coastal city of Chania, Greece was studied in the period 2012-2015 in order to determine potential drawbacks of the urban run-off management system and develop solutions for sustainable protection of the main receiving body, the Venetian harbour. During this study, a citizen's survey was performed that highlighted the lack of knowledge with respect to the environmental threats posed by storm water that ends up in the sea. In this work, six important solutions for the sustainable management of urban run-off of Chania (applicable also to other coastal cities) are proposed and discussed. Additionally, the initial results of the citizen's survey are provided, pinpointing the need for a comprehensive education and information strategy on urban run-off management issues.

Introduction

The sustainable environmental management of the coastal zone is a multi-component issue, common in many coastal cities worldwide. Sea water quality can be affected by inland practices as well as intensive sea water use. In the framework of Archimedes III (Research Program EPEAEK, financed by The European Union & Ministry of Education, Lifelong Learning and Religious Affairs of Greece) the following project was carried out in the years 2012-2015: Decision support tool for the management of urban run-off in coastal cities (COASTSURF). The project's main objectives were a) to review of the current literature on the polluting nature of sewer and storm water run-off, b) the qualitative assessment of the human activities and potential polluting sources and determination of sampling points within the sewer infrastructure of the city of Chania, c) the quantitative assessment of the polluting load, throughout the sewer infrastructure as well as the sea outflow points, d) the development of a mathematical model that would include the hydrodynamic behavior of the sea and will relate the quality of the coastal waters to the urban run-off of the city and the climatic conditions and e) the determination of the Best Available Practices (BAPs) for sustainable management of urban run-off (including a citizen's questionnaire reflecting the public opinion and trends on storm water threats and potential solutions).

The urban runoff infrastructure in the city of Chania (Crete, Greece) has several outlets in the Venetian harbor, which is the most important touristic attraction of the city and one of the most significant of Crete. Storm water flow can carry dust, road depositions and other pollutants and affect the sea water quality of the harbor. Leaks from the wastewater infrastructure or illegal connections to the sewer further increase the polluting load reaching the sea. Additionally, the heavy use of the harbor's marina for recreational purposes (especially the summer months) often leads to pollution incidents.

Results and Discussion

After extensive sampling of the sea water from the Venetian port, it was determined that in many cases the polluting load –especially microbiological indicators such as fecal coliforms and enterococci - was considerably higher compared to guidelines values (Table 1). Therefore, it was established that there is an environmental risk involved in the management of the Venetian harbor and actions for the protection of the sea water quality and marine life are required. The necessary steps for sustainable protection of the Venetian harbor are the following:

1. Development of a digital map of the sewer infrastructure - More than just digital replicas, these maps are linked to millions of bits of information, or attributes — the size of the pipes, the dates they were built and repaired, what they were made of — that can be called up and sorted with the click of a mouse. The maps can be updated instantly when water mains and sewers are installed, removed or repaired.
2. Illicit discharge and connection detection program - Studies have shown that dry weather flows from the storm drain system may contribute a larger annual discharge mass for some pollutants than wet weather storm water flows. Detecting and eliminating these illicit discharges and connections (e.g. old sanitary tanks) involves complex detective work and close cooperation among several parties.
3. Establishment of the total maximum daily loads (TMDLs) for the Venetian harbor and adjacent areas - TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant. The TMDL process is important for improving water quality because it links the development and implementation of control actions to the attainment of water quality standards. TMDLs are developed using a range of techniques, from simple mass balance calculations to complex water quality modeling approaches. The degree of analysis varies based on a variety of factors including, the waterbody type, complexity of flow conditions, and pollutant causing the impairment.
4. Development of national regulation where special measures would have to be taken for building permits that exceed 1000 m^2. It is known that impermeable surfaces (concrete, pavement) largely reduce the storm water that infiltrates to the ground, thus leading to larger volumes of run-off. Therefore, urban run-off measures (such as rain gardens, “green” roofs and others) should become a necessary component of building permits in order to reduce the environmental impact of residential/commercial development.

Table 1. Polluting load in the seawater of the Venetian harbor[a] [1]

pH	BOD_5 (mg/L)	COD (mg/L)	DO (mg/L)	NO_3^- (mg/L)	NH_4^+ (mg/L)	PO_4^{3-} (mg/L)	FC (cfu/100ml)	Enterococci (cfu/100ml)
7.3-7.9	1-10	3.4-31.8	4-8.5	2.6-6.6	0.08-0.4	0.03-1.2	2-4.200	2-530

a. Minimum and maximum values reported

5. Registration of the Venetian harbor to the European Sea Ports Organisation (ESPO) and EcoPorts Network. Serving the principle of “ports-helping-ports” EcoPorts brought

together a network of port professionals from several European ports committed to exchange views and practices and to commonly work towards the improvement of the sector's environmental performance in line with the principles of voluntary self-regulation. Membership to the Organization offers the opportunity to use the well-established EcoPorts tools, Self-Diagnosis Method (SDM) and Port Environmental Review System (PERS)

6. Information and education events for citizens and professionals – understanding how urban run-off is created and the threats it poses, is fundamental for the successful implementation of any hard or soft protective action. Press-conferences, interactive web pages, seminars and workshops in schools are only a few of the dissemination tools available.

As part of the information and education strategy, a questionnaire was developed by the project team and was delivered to 400+ citizens of the city. The objective of this questionnaire was to assess their knowledge on storm water management and eagerness to contribute to potential future actions towards protection of the Venetian harbor. The survey consisted of 14 questions. Selected results can be seen in Figure 1a-f. Figure 1a shows that approximately 1/3 of the citizens did not know what urban run-off is. This is a clear indication that there is a knowledge gap in this subject. This gap was confirmed in Figure 1b – only 55% of the citizens knew that storm water ends up in the sea. It is interesting to note that about 1/3 of the citizens (34%) thought that urban run-off is collected and treated by the wastewater treatment plant of Chania. Only 64% of the citizens were aware of the fact that paints and solvents should be disposed of in the toilet or kitchen sink and not in an open permeable or impermeable surface (Figure 1c). A green roof and a rain garden are two widely available technologies for collection and partial treatment of urban run-off. In recent years, green roofs have been increasingly popular in Greece, especially in new residential and commercial buildings. This reflects in the results shown in Figure 1d, where 83% of the citizens knew what a green roof is. However, this trend was reversed for the rain gardens, where the same percentage were not aware of this technology. This result may be explained by the high population density in all major Greek cities and the fact that most people live in apartments and building blocks, where gardens and green spaces are almost completely absent. Finally, Figure 1f provides some encouraging results with respect to future actions. 66% agreed to a 20 euro yearly charge in their water bill in order to maintain the sewer infrastructure quality.

Concluding remarks

The results obtained from the 3-year study of the urban run-off and sea water quality of the coastal city of Chania, indicate the need for further action, including a comprehensive information and education strategy. The six storm water management actions proposed earlier are applicable to any coastal city but their success will be limited if they are not accompanied by educational initiatives that will target the citizens, professionals and non-professionals alike. The survey results clearly indicate the need for these initiatives, most of which can be applied at a voluntary basis at a low cost. Protecting coastal waters is not only a scientific issue, is more of a complex political issue that requires the cooperation of people from different backgrounds in order to be dealt with.

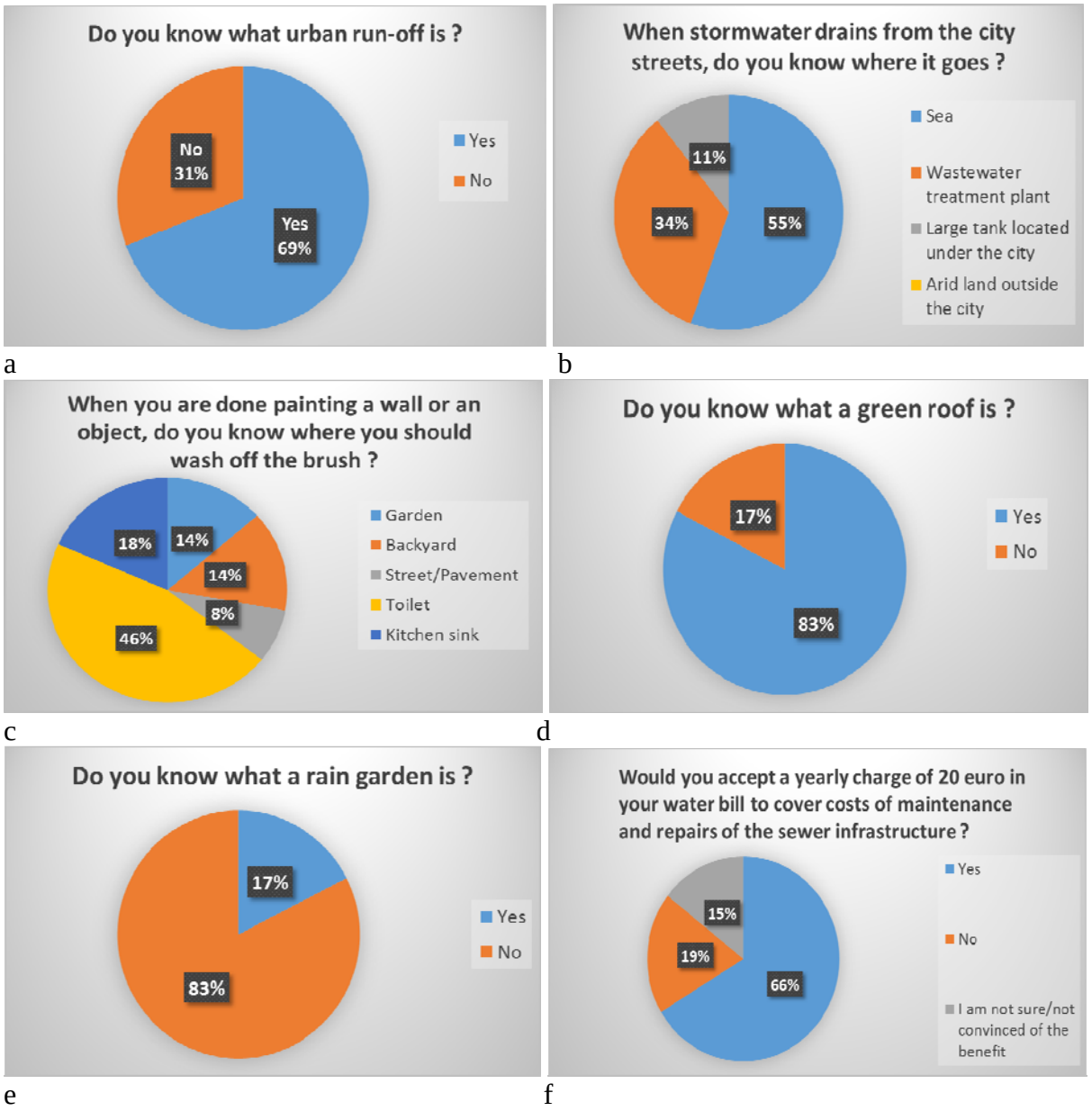

Fig. 1a-f. Selected results of the citizens' questionnaire on urban run-off management

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