

Sustainable development of wastewater treatment & disposal systems in the Eastern Adriatic

Nenad Ravlic*
Water Engineering Section
Civil Engineering Institute of Croatia, Rijeka, Croatia
E-mail: nenad.ravlic@igh.hr

Robert Precali
Institute "Rudjer Boskovic"
Center for Marine Research, Rovinj, Croatia
E-mail: precali@cim.irb.hr

ABSTRACT

Sustainability of wastewater collection, treatment and disposal options in the coastal region of the Republic of Croatia, are discussed in the context of recent large-scale infrastructure investments. Past experiences are used for evaluation of development plans from a sustainability standpoint, bringing into focus the question of selecting the right strategy that would fulfill both population and environmental needs. The DPSIR approach (drivers-pressures-state-impacts-responses) is discussed in the context of the inherent complexity of the wastewater management sector and legislative ambiguities which create the opportunity for different development scenarios in partially sewered small and medium-size coastal municipalities.

BACKGROUND

In the wake of the Croatian Government's intention to improve ambient coastal water quality to meet European Union (EU) standards, the Croatian Coastal Cities Pollution Control Project (The Project) was launched recently as a joint effort of the Croatian Waters (CW), small and medium-size coastal municipalities (SMSCM) and the World Bank (WB).

As stated in [1], the Project is split in several phases and is foreseen to take place in the next 10-year period. The key elements of the Project's first phase are (i) expansion of sewerage networks, adequate treatment and appropriate disposal of municipal wastewaters, (ii) enhanced operation and management of Municipal Water and Sewerage Companies (MWSCs), (iii) expanded and improved monitoring of coastal water quality and wastewater discharges, (iv) reform of Croatia's financing and control instruments for wastewater management infrastructure at the regional level and (v) sector reform for EU accession.

In subsequent phases, the Project aims at expanding and consolidating the results of the first phase through (vi) improvement of sector management through the establishment of financially viable water and sewerage companies with significant participation of the private sector and (vii) further development of sewerage coverage and treatment levels, including the reuse of wastewater.

* Corresponding author

Out of the first 4 sub-projects, two SMSCMs in the Northern Adriatic (Opatija 46.000 P.E. Krk 30.000 P.E.) were evaluated and identified as eligible for the first year of the Project implementation. Accessible financial resources will be invested into construction/expansion of sewerage networks, main collectors, pumping stations, wastewater treatment plants (WWTPs) and submarine outfalls, with the main goal to reach ambient water quality EU standards in the subproject area.

SUSTAINABILITY ASPECTS OF THE PROJECT

Is wastewater really the waste ?

Natural waters resources are defined as public "good" without proprietary (the definition taken from the governing national regulation, Off. Gaz. 107/95).

It is interesting to note that no similar definition is provided for wastewaters (public "bad", by analogy ?). Considering that wastewater = natural water (99%) + waste matter/energy (1%), it shouldn't be so easily/arbitrarily expelled from the regulations. And for sure, by no means from the water cycle !

Therefore, the term *waste* doesn't imply the possibility of permanent elimination of such waters from the water cycle. It could denote only transitional state from *pure* to acceptably polluted waters which are eventually handed over to the Nature after being subject to certain treatment, preferably the *appropriate* one. Who should decide on the appropriateness of treatment, Man (laws) or Nature ?

Man has powerful and versatile tools in his hands, while the Nature will not act adversely if the discharged wastewater contains mainly natural substances, recognized by the Nature as being natural. The Nature will be seemingly grateful (or maybe not ?) for adding in artificial energy to feed a process on land, knowing that this energy is the same one that could have been used more efficiently by the Nature itself.

Costs? The Nature doesn't recognize that term, it is the Man who has invented it for his own purposes. Sustainability ? It is only the Nature to decide on sustainability which, unfortunately, cannot be guaranteed in advance. Being the final consequence of the process where Man constantly challenges the Nature (often trying to know its limits), sustainability (whatever it is) can be regarded as the natural response to the Man's action, whatever it is. What is shown to be sustainable in one case is maybe not in another. That's why the Man has to take close look to the Nature's responses to his past actions in order to have sufficiently reliable lever for his further actions. Evolution or revolution, it's up to Man to decide. The Nature has already prepared all answers, it's only about to make it unveil or kept hidden.

Sustainability of the national legislation on wastewater treatment

"The chain is as strong as its weakest link" (an old saying).

"Public Wastewater Drainage System: **integrated** system consisting of wastewater and sludge collection/treatment/disposal facilities" (definition taken from the governing national regulation, Off. Gaz. 8/99).

Integration of the above statements and translation into vocabulary of more explicit technical language in the field of wastewater management & engineering in coastal areas in so called "countries in transition" could result in the following extreme conclusion: the effort is sound and reasonable if you do everything (not feasible, by the way). Otherwise, partial efforts are by definition in conflict with the concept of system's integrity where the weakest link determines the strength of the chain. Is there any acceptable and reasonable option in between ?

The answer is positive, at least when coastal areas in the Republic of Croatia are considered and fortunately, that was recognized by the Project decision makers in spite of a number of (legally founded, thus legitimate) obstacles that could have been raised by certain environmentalist circles supported by partially informed public opinion, who advocate strict and prompt application of all prevention measures (min. 70% sewerage coverage, immediate implementation of legally prescribed levels of treatment depending on the agglomeration size) before treated effluent is discharged into receiving coastal waters.

In the context of governing national regulations and ambiguities contained therein, the order of appearance of the Project's key elements could have been differently arranged. Immediate implementation of high-tech on-land solutions aimed to provide *necessary* treatment levels instead of *appropriate* ones could have been unjustly given priority without sufficient sustainability pre-conditions being created beforehand.

The term *appropriate treatment*, already recognized in the EU regulations (91/271/EEC) as "treatment of urban waste water by any process AND/OR disposal system which after discharge allows the receiving waters to meet the relevant quality objectives and the relevant provisions of this and other Community Directives" was transferred in 1999. into governing Croatian regulation (Official Gazette 8/99) which states: "*appropriate* treatment means treatment of urban waste water by any process OR disposal system which after discharge allows the effluent AND receiving waters to meet the relevant quality objectives".

At a first glance, no substantial changes were introduced with respect to the original EU definition. However, better insight into the logic of the semi-cloned definition reveals the logical mess that was created by anticipating two equally valid, thus ALTERNATIVE, options of *appropriate* treatment (on-land treatment OR marine treatment) and later conditioning by the provision that BOTH effluent and the recipient standards have to be met simultaneously if the treatment in concern aspires to become *appropriate* one.

Obviousness of the fact that effluent quality is controlled upstream to the recipient leads to the conclusion that effluent standards are to be understood as (necessary) precondition, while the recipient standards are the (desired) consequence which, in turn, becomes (sufficient) precondition for the treatment (taking place upstream) to be effectively *appropriate*.

In the situation when both types of standards play dual precondition-consequence role, one can make the following questions: which one prevails, effluent OR recipient standards, as anticipated initially in the argued definition ? What happens if recipient standards can be met without attaining to (strictly prescribed) effluent standards ? Can that kind of treatment be regarded as the *appropriate* one ?

If the answer to this question is positive, marine treatment can obviously be regarded as a part of the overall treatment scheme (on-land + marine treatment) and the recipient standards are the governing ones. Otherwise, *appropriate* treatment would consist of on-land component only, which implies the negation of the premise that disposal systems can be regarded as equally valid alternative solution. Quite a mess !

The above logical analysis is not of academic nature only and could play very important role in the Croatian coastal area, where long submarine outfalls (equipped with properly shaped diffusers) and accompanying marine treatment have been proven in a number of documented examples to be capable to ensure not only the receiving waters to meet the relevant beach water quality objectives but to comply with even more stringent regulatory mixing zone requirements (except bacteriological standards).

The EU directive has prescribed less stringent treatment criteria for discharges into less sensitive areas for all sizes of agglomerations, including those with more than 150.000 p.e. Is there any justifiable reason to abandon that provision in cases where less sensitive areas can be easily reached by safe and proven submarine disposal facilities ?

The authors' answer to this question is clear and sharp: no ! In that context, the above discussion on the *appropriate* treatment is far less important and the choice of on-land treatment level would depend only on the recipient's sensitivity issues.

Therefore, in Croatian circumstances (especially for SMSMs) it seems obvious that selection of the *appropriate* level of treatment MUST start with and rely only on the approach based on the recipient's sensitivity and assessment of its ecological status, while effective action based on non-flexible legal provisions on *required* treatment levels could wait until all links in the chain are developed to the extent that would enable their effective integration.

In that context, the authors welcome the Project's approach which abandons investment selection driven by OUTDATED effluent standards and promotes an **impact approach** that allows prioritizations to obtain maximum benefit in terms of receiving water use and quality.

Sea state indicators and DPSIR approach

The term *indicator* generally describes a compact, yet effective way to present given environmental information in a format that is best suited to inform about subsequent response in environmental management. The definition of an *indicator* according to OECD (1993) is: "Indicator/parameter or a value derived from parameters, which points to, provides information about / describes the state of a phenomenon / environment / area and has further implications for the environment. The indicator is not necessarily an environmental parameter, but it could be the expression of a parameter or a pool of environmental parameters. A good indicator has to meet a set of criteria".

In relation to policy-making, environmental indicators are used for three major purposes:

1. To supply information on environmental problems in order to enable policy-makers to assess their seriousness;
2. To support policy development and priority setting by identifying key factors that cause pressure on the environment;

3. To monitor the effects of policy responses.

In addition, environmental indicators may be used as a powerful tool to raise public awareness on environmental issues. Providing information on driving forces, impacts and policy responses is a common strategy to strengthen public support for policy measures.

The DPSIR, which stands for **D**riving Force, **P**ressures, **S**tate, **I**mpact and **R**esponses, is an approach to the system of indicators widely accepted for the marine environment and coastal zone aimed to obtain: an information reporting system (a structure for organizing and reporting on monitoring data); a tool for communicating with policy-makers in particular and also with the general public; a tool for improving understanding of environmental problems; an information and assessment tool for identification of environmental problems; a tool to set priorities for regional environmental problems.

The framework adopts a causal approach and identifies the causal chain. The indicators are the attributes of the framework, they summarize information or, more specifically, the raw data concerning selected issue or problem. This approach applied to the problem of eutrophication (the main problem associated with wastewater deposition in Croatian coastal waters) is presented in Fig. 1.

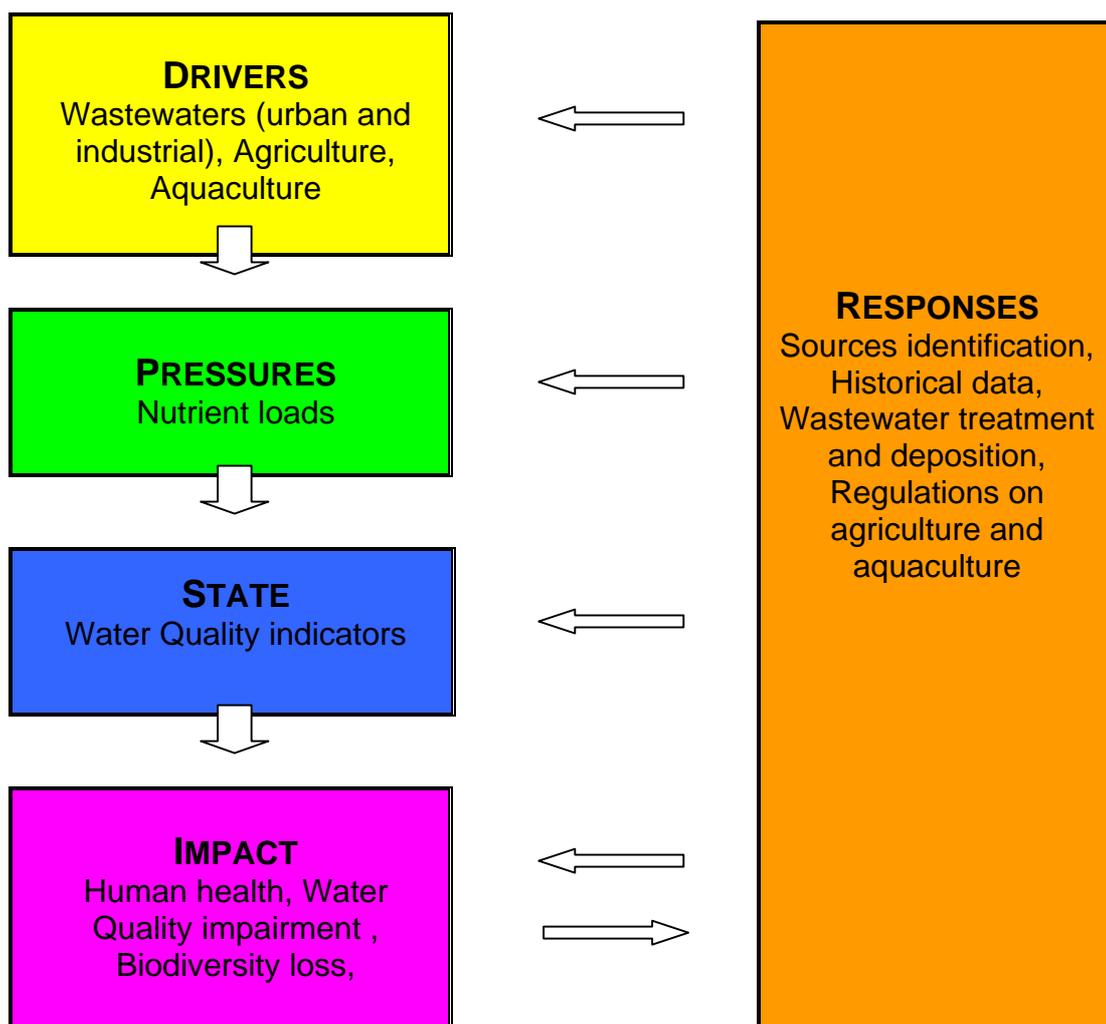


Figure 1. DPSIR approach applied to eutrophication in the Croatian coastal waters.

Coastal zones are complex environments, influenced by many inter-related forces related to hydrological, geomorphological, socio-economic, institutional and cultural systems. The close links (through both human and physical processes) between marine and terrestrial component of coastal zones imply that coastal zone management should always consider both the marine and terrestrial portions of the coastal zone, as well as the river basins draining into it.

In the last years new criteria for classification of the state of marine and coastal environment are emerging [2]. Particularly, the trophic state of marine and coastal waters is characterized through the trophic index (TRIX) based on chlorophyll a, oxygen saturation, inorganic nitrogen and total phosphorus [3]. Numerically, the TRIX index is scaled from 2 to 8, covering a range of 4 trophic states. The parameters to be included in this trophic index are selected as directly related to the eutrophication phenomena. An example of trophic state evaluation along the Croatian coast is presented in Fig. 2.

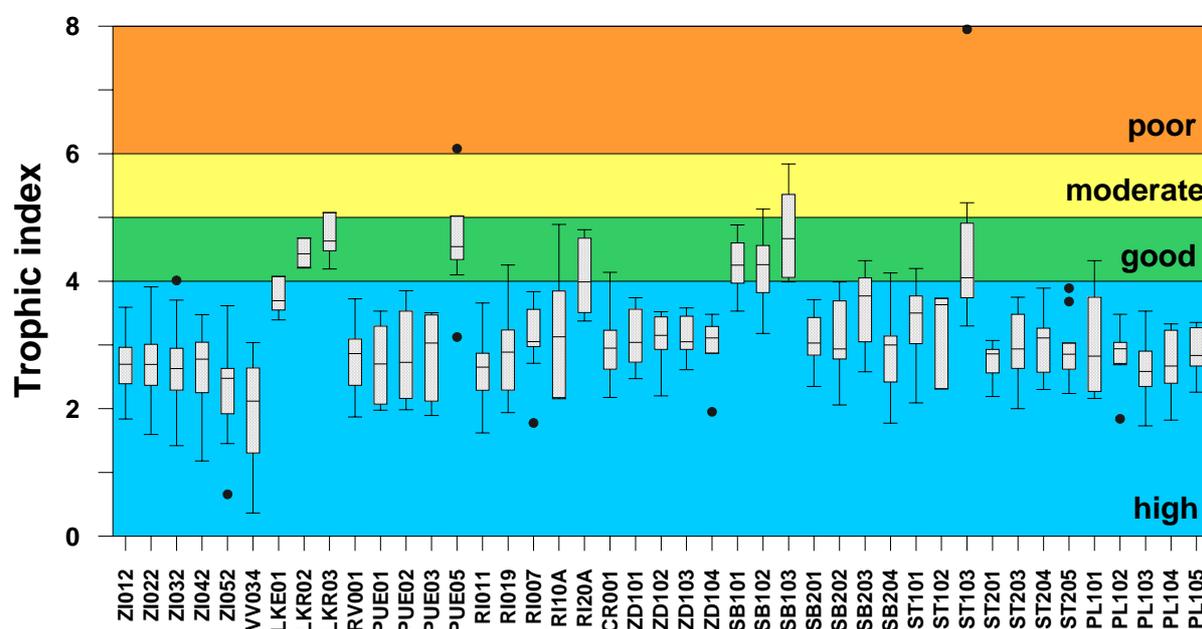


Figure 2. Box and Whisker presentation of trophic index along the Croatian coast for the period 1998-2000. [†]

In addition to marine quality indicators (like TRIX and ecological status), additional subset of indicators dealing with the Pressure part of the DPSIR model has to be developed as well. When dealing with coastal urban areas, water consumption and wastewater production rates, percentage of treated water and percentage of population connected to the system will surely be among the most important ones on the pressure side of the model.

However, other measurable indicators related to management of wastewater systems (performance indicators, PI) are to be included in the model as well. Each PI, typically expressed as ratio between variables, should contribute to the expression of the level of actual

[†] Sampled stations are located as follows: ZI-western Istrian coast, VV-Kvarner Bay, LK-Lim channel, RV- Rovinj, PU-Pula, RI-Rijeka, CR-Crikvenica, ZD-Zadar, SB-Sibenik, ST-Split and PL-Ploce. Data were collected in the frame of the “Adriatic Project”.

performance achieved, allowing for a clear comparison with targeted objectives and taking into account the context in which the wastewater system operates. One good example of guidelines for assessment of the services related to the management of wastewater systems is presented in [4].

The above marine quality and wastewater system performance indicators are representing the core of DPISR indicators which should be centered on the flow of data and information from monitoring to reporting. Set-up of the basis of Monitoring-Data-Information-Assessment-Reporting chain (MDIAR, already implemented in the European Environmental Agency) has been given high priority within the framework of the Project, confirming the awareness of the decision makers that all (technical) actions should rely on measurable parameters, with minimum personal or subjective appraisals involved.

Wastewater management issues

Within the context of Croatia's decentralized system of public administration, adoption of a stepwise approach and least-cost solutions in the first phase of the Project (i.e. appropriate pre-treatment on land + marine treatment = adequate overall treatment) seems to be the only reasonable way capable to ensure that necessary surcharges to the current tariffs do not exceed the levels that are affordable for the population.

Even if affordability and insufficient sewerage coverage issues were neglected, existing institutional framework and policy arrangements (municipally-focused set up in Croatia) wouldn't make sustainable the alternative approaches relying on immediate investments into advanced wastewater treatment systems, no matter how big or small they are. Why ?

The answer to this question, which stays in the roots of anticipated wastewater sector reform in later stages of the Project, is very simple: approach based on investments borne by municipalities (network owners and managers) with bulk of economic benefits accruing (only) at WWTPs is a priori not acceptable (thus non-sustainable, by definition) for those parties who justly realized that the role of wastewater "providers" (or providers of the "raw material" for future advanced processes) is ensuring them much better and more competitive start position on the future market, with treatment plants in the focus of (private and/or private/public) interest.

By understanding that strategic institutional reforms at the sector level need more time to find out the best option adjusted to local conditions, the Project decision makers have chosen the right strategy that will enable the decisions to be made as close as possible to the locations where wastewater is produced and coastal waters are affected.

Some recent (sub-regional) studies [5] on organizational aspects of water protection sector in the Republic of Croatia have clearly confirmed that the choice of best institutional/organizational option is all but simple task, with a number of different and mutually exclusive interests involved (centralization/decentralization), depending on the state of development of different sub-systems. In that context (where the bulk of discussions is still focused on proprietary issues), it seems reasonable to give more time to the stakeholders to reach the agreement in more mature circumstances.

One thing is sure, though: small and medium sized municipalities are not powerful enough to face the overall wastewater problem by themselves and state contribution/assistance in excess to water pollution fee recovery seems to be absolutely needed. That's was, in fact, the main strategic lever for the government to launch the Project and search for external funding.

Within the context of transition towards clear identification of different economic interests, aspirations and responsibilities in wastewater management sector, the Project investments into main components of local sewerage systems can be seen as a good opportunity to generate new and challenging "gradient" of interests, where municipalities could be faced with the challenge of potential taking over of the control package by others if they do not engage their own resources for additional investments into secondary network extensions (double effect of the investment).

CONCLUSIONS

With no apriorities as to the advanced wastewater treatment systems in small and medium sized coastal municipalities in the Republic of Croatia, the selection of the appropriate and sustainable level of treatment **MUST** be based on the recipient's sensitivity considerations and assessment of its ecological status. This can be accomplished through the selection of a good core of DPISR indicators and centered on the flow of data and information from monitoring to reporting (MDIAR chain).

Inclusion of wastewater system performance indicators in the MDIAR chain would surely increase and optimize the overall effects of forthcoming investments in Croatian coastal municipalities, with minimum personal or subjective appraisals involved in the decision making process. These advantages should not be neglected in the area where technical feasibility has been so often proven to be the first step towards non-sustainability and/or creation of collateral environmental conflicts in space-limited coastal strips.

REFERENCES

1. The World Bank, Croatian Coastal Cities Pollution Control Project, Report No. 27759-HR, 2004.
2. EEA, Eutrophication in Europe's coastal waters, Topic report 7, pp. 86, 2001.
3. Vollenweider, R.A., Giovanardi, F., Montanari, G. and Rinaldi, A. Characterization of the trophic conditions of marine coastal waters with special reference to the NW Adriatic sea: proposal for a trophic scale, turbidity and generalized water quality index. *Environmetrics*, **9**: pp. 329-357, 1998.
4. ISO/TC 224, Management of Wastewater Systems – Guidelines for the assessment of the service, Working draft of WG4, Daejeon Korea, 2004.
5. Civil Engineering Institute of Croatia & others, Sea and Water Protection Study in the County of Primorje & Gorski kotar, Rijeka, 2004.