EUTROPHICATION AT ELEFSIS BAY

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ABSTRACT

Research and studies in the Elefsis Bay, Greece (*Figure 2*), has revealed a great abundance of physic-chemical and biological characteristics, the later 30 years. Moreover, the enrichment of nutrient substances results to the sudden algal growth. This phenomenon is known as eutrophication. This is a natural phenomenon. However, human activities increase the concentration of nutrient substances into the natural waters. This results to an enormous increase of eutrophication. The natural development of this phenomenon takes millennia, whereas, human activities may result to the phenomenon in only a decade. [1,3]

Due to organic carbon and phytoplankton high concentration, the Elefsis Bay, has been classified as in a bad condition status. This status causes the phenomenon of eutophication. Problems that are being observed are mainly (i) phytoplankton bloom and (ii) and high concentration sediments. Moreover, anthropogenic activity, leads to the formation of organic material which is disposed to the bottom of the sea and results as the degradation of the sediment status. This, along with the moderate status of Psitalia sea floor, contributes to the bad overall status of the area.

Eutrophication, results to the presence of anaerobic conditions, odor emissions, creation of hazardous and noxious substances, degradation of dissolved oxygen concentration, and the death of any of the aquatic life form. Periodically, increased concentrations of metal, phytoplankton and biomass are being observed. Last but not least, research demonstrates that the system is recovering and observes the recovery time that is needed.[1-2]

All research results and findings apply to scientists, managers and policy makers. With the use of MSFD (Marine Strategy Framework Directive) they need to decide which method they should apply in the communication and in the assessment of the sea environmental status [1].

KEYWORDS

Elefsis Bay; Eutrophication; Mediterranean Costal Area; Saronikos Gulf; Water Pollution

1. INTRODUCTION

Men driven actions cause the seas and their services degradation of marine ecosystems by threatening their functioning, structure and integrity, because of pollution, habitat degradation and resource depletion.

With the use of various instruments, such as: Marine Strategy Framework Directive (MSFD), Marine Spatial Planning Directive (MSPD), and Ecosystem-Based Management (EBM), the sustainability challenges which Europe Union (EU) faces in marine ecosystems are being managed. Those challenges deal with eutrophiacation, chemical pollution,

biodiversity, climate change, and other factors resulting from socioeconomic activities.

In specific, there was a target being settled by 2020, by MSFD, aiming to achieve Good Environmental Status (GES) within the Member States (MSs). That aimed that the marine environment has an implemented and integrated approach, so that anthropogenetic activities are being managed and achieved. [1]

According to the UNEP (2013), in the framework of Barcelona Convention, along within the full synergy of MSFD, the implementation of EBM has been committed by the Mediterranean countries. (UNEP, 2013)

There has been an aggregation of different indicators, MSFD descriptions and ecosystem components, at a variety of temporal and spatial scales that access the environmental status of marine systems. (Borja et al. Review, 2016a) [1]

2. METHODOLOGY

In order to access different geographical areas and ecological system components, scientists used free software (NEAT), available at www.devote-projects.eu/neat Scientists with the use of NEAT, were targeting to access the environmental status under the MSFD. To achieve that, they followed certain principles of NEAT. The main principles are the following:

- Indicators
- Hierarchies and weighting procedures
- Indicator aggregation
- Result confidence

Application of the NEAT version 1.3 at Saronikos Bay, part of which is Elefsis Bay, was approached by the following techniques:

- Deviation into five industrial zones: Inner and Outer Saronikos Gulf, Western Basin, Psitalia sewage outfall and last but not least Elefsis Bay. All the above industrial zones, describe as a whole, all Saronikos Gulf, so Saronikos Gulf was tested as a whole.
- Deviation into two habitat types: pelagic and benthic (sedimentary and rocky).

Statistical analysis, spatial analysis involving all indicators and filtered descriptor, resulted that eutrophication in Elefsis Bay is expressed by high organic sediments and an enormous phytoplankton bloom. All the above classify Elefsis Bay into poor status. [1]

3. RESULTS AND DISCUSSION

3.1.1 Results

As a result of eutrophication, in the waters of Elefsis Bay, formation of aquatic microorganisms has taken place, as well as low opacity index.

The formation of aquatic microorganisms, leads to fish loss; and fishery and sea navigation damage. Low opacity index sets the waters of the Bay inappropriate for swimming and those that swim get allergies.

Finally, because of eutrophication, the flow of irrigation ditches is being changed.

3.1.2 Discussion

We examine eutrophication, and more specifically in this project, eutrophication in Elefsis Bay, because of an imperative

need of today's society, the achievement of sustainable development. Sustainability is broadly defined "*as development meeting current needs of society while ensuring that future generations' needs are met*" [8], and is being characterized by three basic dimensions (Figure 1):

- Social
- Environmental and
- Economic

Eutrophication is being located all over Greece's waters, such as lakes and seas. Elefsis Bay is at Eastern Mediterranean, part of Saronikos Bay (Figure 2).

Eutrophication is being monitored in all over Greece. Environmental and biological data derived from the WFD (Hellenic/Greek European Water Framework Directive) [9] – (Figure 3).

Main stress factors like PO_4, NO_3, POC and Cd, at Hellenic coastal bodies, have been plotted at Figure 4. There are cases that have been excluded, like Korinthiakos Gulf, due to unavailability of more than 15 elements, like O_2 – standard deviation (SD)- all with the use of PCQ (physiochemical quality index), which was developed by Bald et al. (2005) [9]-(Figure 4).

But what is eutrophication? A great abundance of nutrients, results to a sudden growth of algae in the lakes, rivers and in seas. This phenomenon is being called eutrophication and results to the development of anaerobic conditions, the reduction of dissolved oxygen (anoxia/hypoxia), stench emission, formation of toxic substances and the extinction of any kind of aquatic life form (creation of azoic zones).

Eutrophication is a natural phenomenon, which is being reinforced by human activities. The natural evolution of eutrophication takes millennia, whereas anthropogenetic pressures may accelerate it in only a decade.

Eutrophication develops because of the presence of nutrients in the waters. Nutrients are essential for the formation of organisms. The elements of: C (carbon), N (nitrogen), P (phosphorus), and S (sulphur) are the compounds of nutrients. But the term nutrient is mainly used for the N, and P compounds. These elements are present in small concentration in the waters and limit the algae formation. But, by increasing the concentration of nitrogen (N) and sulphur (S) leads to algae growth and therefore eutrophication.

Eutrophication, a form of water pollution, is created because of industrial activity and because of the accumulation of the westerns' channel waste. The increased consecration of metals, biomass, and phytoplankton, characterizes the bad condition of Elefsis Bay and the formation of the phenomenon of eutrophication. [1, 3]

Elefsis Bay morphology creates a seasonal thick layer, in the volume of the Bay, which affects the volume of oxygen distribution at the bottom of the sea and leads to hypoxia and anoxia for at about five months. It is believed, that because of this water condition the nutrients are being sustained at the bottom of the Bay and the low concentration of nitrogen, characterizes the sea water of the Bay as anoxic.

There is evidence that in the past centuries, in the climatic history of Earth, the area was impacted of hypoxia/anoxia. Elefsis Bays' hypoxia during geological periods seems to be caused because of climate changes. Periods, where the temperature was high, seem to lead to higher productivity, the main reason for the formation of hypoxia in the Bay.

Over the time diversity of biochemical descriptors, develop an important rise to the N: P rate, as well as an important reduction to chlorophyll. This fact causes a remarkable improvement to the status of Elefsis Bay, after 2000. This improvement to the status of the Bays' water is because of the operation of Psitalias' Sewage Treatment Plant (STP), at the end of 1994. [1-2, 4]

There are other studies which investigated the status of Saronikos Bay, besides the one with the NEAT method. At Table 1, we can see the comparison of various studies of Saronikos Bay. [1]

The ecological system of Elefsis Bays' water appears to be:

- complicated
- diverse and
- volatile

First indications in seasonal trends at the nutrients of the Bay, suggest that there is pollution reduction the latest ten years because of the operation of STP, rather than climate change. On the other hand, climate changes seem to affect the phenomena of hypoxia and anoxia that are being observed in the Bay of Elefsis.[1, 2, 4]

3.2 Figures, Tables

Figure1. Sustainable Dimensions [9, p8]

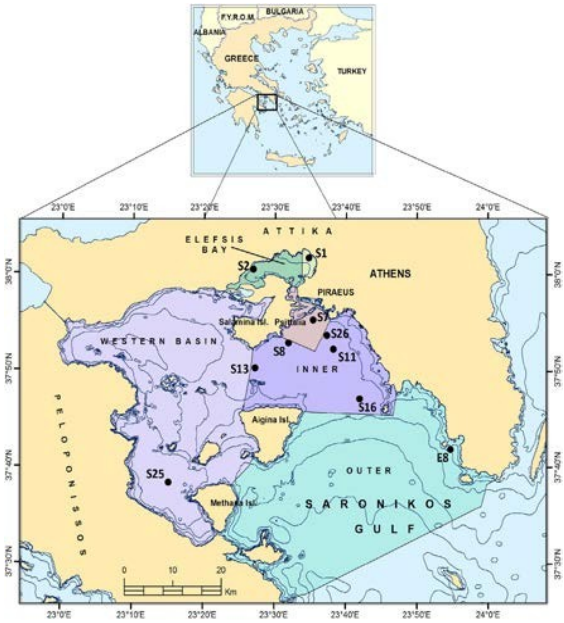

Figure 2. Case study of Saronikos Gulf and the spatial station and assessment units used. [1,,p337]

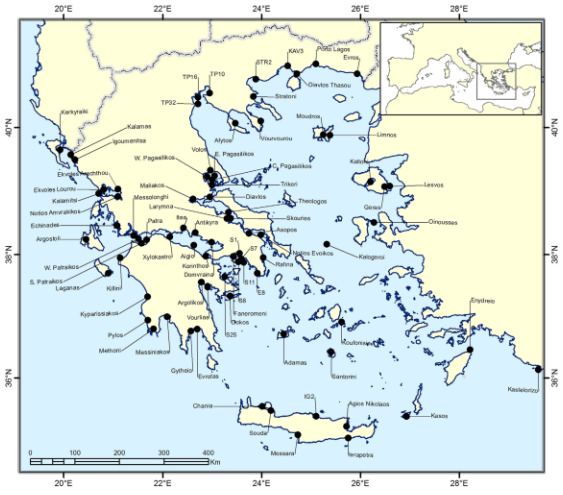

Figure3. Monitoring network, where environmental and biological data were derived from the Greek (Hellenic) European Water Framework Directive-WFD. [4, p.96]

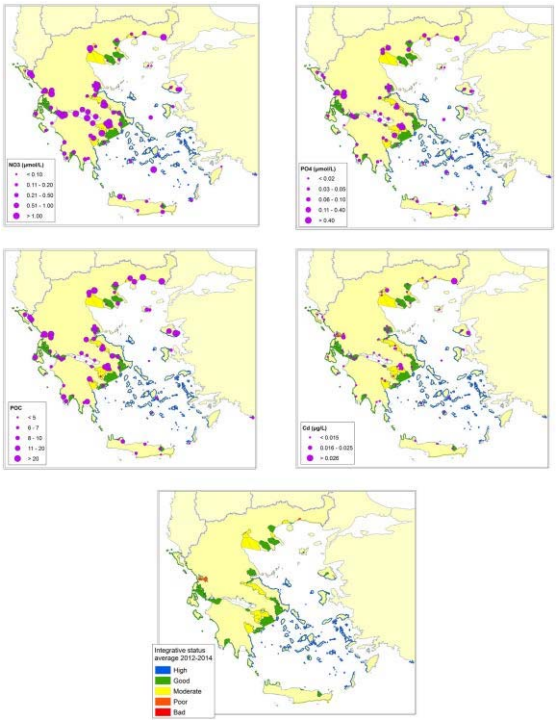

Figure4. Hellenic (Greek) costal bodies, where NO_3, PO_4, POC, and Cd, – main stress factors- have been plotted. Limited cases have been excluded, (like Korinthiakos Gulf), due to unavailability of almost 17 values, like NO_3, PO_4, Cd etc. [4, p.101]

. Comparison of the assessment results for Saronikos Gulf with those of other studies.

	Simboura *et al.*, 2005	Uusitalo *et al.*, 2016	Simboura *et al.*, 2014	Simboura *et al*, 2016	Present study
Data period	2000-2004	2000-2012	2012	2012-2015	2000-2016
Integration method (indicator level)	One-out-all out	NEAT	Two-out-all out	Decision tree	NEAT
Integration method (spatial level)	One-out-all out	NEAT	One-out-all out	One-out-all out	NEAT
No of indicators	3	17	2	13	24
Psittalia	Poor	Poor	Moderate	Moderate	Moderate
Elefsis Bay			Poor	Moderate	Poor
Inner gulf	Moderate	Moderate	Moderate	Moderate	Good
Outer gulf		Moderate (only fish & alien)		Good	High (all indicators)
Overall		Moderate			Good

Table1. Comparing the status of Saronikos Bay, with the status of the Bay, of other studies. [1, p.348]

4. CONCLUSIONS

Concluding, the local climate diversity, which is being developed because of eutrophication, influences directly/ indirectly the phenomena of anoxia and hypoxia that are present in the Elefsis Bay.

Comparing the human interference caused by the WTP (Waste water Treatment Plant) to climate change, one can say that the WTP resulted positively by reducing the pollution of the sea in Elefsis Bay, whereas climate change in local, regional or global scale, has the potential to affect the marine and costal ecosystems (phenomena of anoxia/hypoxia) by reducing O_2 concentration in levels less than 1ml/lt. This way the benthos can be characterized and as azoic. [8]

All these findings and results can be used by decision makers, by scientists, by managers and by policy makers. By using Marine Strategy Framework Directive (MSFD) they decide which method to apply for the communication and assessment of the sea environmental status. With the use of MSFD (Marine Strategy Framework Directive) they need to decide which method they should apply in the communication and assessment of the sea environmental status. [1]

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