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Discussion of Biological Monitoring Categories of Water Pollution and Application of These Models to West Marmara Coasts

Su Kirliliğinin Biyolojik İzleme Kategorilerinin Tartışılması ve Bu Modellerin Batı Marmara Kıyılarına Uygulanması

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ÖZ

Türkiye'deki mevcut kullanılabilir su kaynağının kullanım oranı % 35-36 civarında olup bunun, 7 milyar m3'ü %60 içme ve kullanma suyu olarak, 5 milyar m3'ü %40'ı ise sanayide kullanılmaktadır. Türkiye'de 1990'lı yıllardan beri UNEP tarafından koordine edilen MEDPOL programı kapsamında, Akdeniz ve Ege Denizi'nde deniz kirlilik izleme programı uygulanmaktadır. Ayrıca, 2004 yılından itibaren Karadeniz'de de kirlilik izleme sistemi oluşturulmuştur. 82 izleme noktasında 95 parametrenin ölçümüne dayalı izleme sistemi kapsamında nehirlerin taşıdığı kirliliğin saptanması için nehir ağızlarında da izleme yapılmaktadır. Türkiye'de çeşitli kurumlar aracılığı ile su kirliliği izleme çalışmaları yürütülmekte, yapılan bu kirlilik izleme çalışmaları çoğu kez birbirinden bağımsız şekilde yürütülmektedir. Bu çalışmalara rağmen Türkiye'de Entegre bir kirlilik izleme stratejisi ise uygulanamamaktadır. Bu çalışma, yeni stratejiler ve projelerin geliştirilmesi hususlarını ortaya koymaktadır. Ayrıca bu stratejiler Batı Marmara Kıyıları için de uygulanmıştır.

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ABSTRACT

The usage rate of available water supply in Turkey is around 35-36 %; 7 billion m3 of this constitutes the 60 % of it and is used as drinking and tap water, and 5 billion m3 that is constituting the 40 % is used in industry. Within the context of the MEDPOL programme which is coordinated by the UNEP since the 1990s in Turkey, a marine pollution observation programme is practiced in the Mediterranean and Aegean Seas. Furthermore, a pollution observation system has also been established in the Black Sea since 2004. In order to determine the pollution that rivers carry, the estuaries are observed in the framework of an observation system which is based on the measuring of 95 parameters on 82 observation points. Various institutions carry out water pollutions observation studies in Turkey and these pollution observation studies are usually carried out independently. An integrated pollution observation strategy is not applicable. This study highlights the importance of developing new strategies and projects.

1. Introduction

Various institutions in Turkey carry out studies to observe water pollution. Most of these water pollution observation studies are followed independently and an integrated pollution observation strategy cannot be practiced. Water Pollution Control Regulation measures with 38 parameters are shown in Table 1 (Baltacı and Onur,2008).

Within the scope of the MEDPOL Programme which is coordinated by UNEP in Turkey, there is a sea pollution observation programme that continues since 1990s in the Mediterranean and Aegean seas. In addition to this, since

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2004, a system to observe the pollution in the Black Sea has been initiated and still continues. At 82 observation points, as part of the observation system based on the measurement of 95 parameters, there is also observation at estuaries in order to determine the pollution that rivers carry (Ministry of Forestry and Water Issue, 2012).

In the scope of Water Products Regulation appendix V and VI, water quality observation is done four times a year in a total of 900 stations at fish production zones (at seas and inland waters). Due to "Regulation for the Protection of Water against Agriculture Based Nitrate Pollution", the Nitrate parameter is observed in about 600 subterranean and 1000 surface water, in a total of 1600 stations

The systematic water quality observations in Turkey are based on chemical quality elements. As the system does not include biological observation or stages such as determining the ecological status after comparing the current situation to referred situation, it cannot be evaluated as in compliance with SÇD (Strategic Environmental Evaluation). Table 1 lists the observed chemical quality elements (Gray, 2005). In addition to these, İSKİ (İstanbul Water and Sewerage Administration) in İstanbul carries out a crucial amount of observations along the coast since 2000.

2. The Aim of the Study

The aim of the study is to provide sustainable water usage to preserve water sources for a long time period; to decrease the discharge and emission of priority substances and to protect and improve the aquatic ecosystem with special precautions like preventing the discharge of priority substances or decommissioning them; to decrease the pollution of subterranean waters and prevent them from getting polluted; to function "Determining the Swimming Water Profiles of Turkish Coasts" which will contribute to lessening the effects created by floods and drought.

2.1. Biological Water Quality in Turkey

Turkey is a bridge between two continents, Asia and Europe, and in a position in which climatic and geographical conditions change due to its position. While there are 12.500 gymnosperms and angiosperms in the whole European continent, there are approximately 11.000 species in Anatolia alone. One third of these are endemic species to Turkey (Ministry of Environment and Forestry, 2007). This distinct biodiversity that Turkey has is significant.

As a result of this, the biological diversity is quite high. The number of invertebrate species is approximately 19.000 and nearly 4.000 of these are endemic subspecies. Our country does not have a biological water quality management method which is developed to determine the pollution of our inland waters. However, biological water quality methods have been practiced in our country recently, and there is a significant rise in the number of limnological studies.

Table 1. Quality Elements Observed in Turkey

Parameter	DSİ-lab, 2010	Ref-lab 2010	Mobil Ref-lab (2010)	Sea	Wetlands	Special Environment Protection Areas	Subterranean Waters	2014 Aims	2018 Aims
Temperature (ºC)	✓	✓		✓	✓	✓		✓	✓
Dissolved Oxygen (DO)	✓	✓	✓	✓	✓	✓		✓	✓
Secchi Depth	✓	✓		✓	✓	✓		✓	✓
pH	✓	✓	✓	✓	✓	✓		✓	✓
EC			✓	✓	✓	✓	✓	✓	✓
Color	✓	✓			✓	✓		✓	
Blurriness	✓	✓		✓	✓	✓		✓	
Total Dissolved Solid Matter	✓	✓						✓	
Suspended Solids (SS)	✓	✓	✓	✓	✓	✓		✓	
alkalinity	✓	✓			✓	✓	✓	✓	
Salinity/Chlorur	✓	✓		✓	✓	✓	✓	✓	✓
Calcium	✓	✓			✓	✓		✓	
Magnesium	✓	✓			✓	✓		✓	
Hardness	✓	✓						✓	
Sulphate	✓	✓	✓		✓	✓	✓	✓	
Sulphite			✓						
H_2S			✓	✓					
Sodium	✓	✓			✓	✓		✓	
Potassium	✓	✓			✓	✓		✓	
Total Nitrogen	✓	✓	✓		✓	✓		✓	
Nitrite	✓	✓	✓		✓	✓		✓	✓
Nitrate	✓	✓	✓		✓	✓		✓	✓
Ammonium	✓	✓	✓		✓	✓	✓	✓	✓
Total Phosphor	✓	✓	✓		✓	✓		✓	
Orto Phosphate	✓	✓			✓	✓		✓	✓
Biological Oxygen Demand	✓	✓		✓	✓	✓		✓	✓
Chemical Oxygen Need (COD)	✓	✓	✓		✓	✓		✓	✓
Total Organic Carbon (TOC)	✓	✓						✓	✓
Organic Matter	✓	✓						✓	
Silica	✓							✓	
Fluoride	✓							✓	
Free Chlorine	✓							✓	
Free CO_2	✓							✓	
Bicarbonate	✓				✓	✓		✓	
Iron	✓	✓			✓	✓		✓	
Manganese	✓	✓			✓	✓		✓	
Aluminium	✓	✓						✓	
Boron	✓	✓						✓	✓
Chromium (VI)	✓	✓						✓	✓
Heavy Metal	✓	✓			✓	✓	✓	✓	✓
Suspended Solid Heavy Metals								✓	
Pesticide (Dissolved)	✓				✓	✓		✓	
Pesticide Suspended Solid								✓	✓
Phenol			✓						
Volatile Substance					✓	✓	✓		✓

Petrol Hydrocarbons	✓		
PAH	✓	✓	✓
Pentabromodi fenyleter			✓
C10-C13 Chloroalkans			✓
Pentachlorobenzene		✓	✓
Hekzakloro benzen		✓	✓
Hekzakloro butadien		✓	✓
Pentaklorofenol		✓	✓
Chlorfenvinfos		✓	✓
Diuron		✓	✓
Isoproturon		✓	✓
Isodrin		✓	✓
Di(2-etil) fitalat DEHP			✓
Detergent	✓		
Nonilfenol			✓
Oktilfenol			✓
Tributiltin			✓
Triklorobenzen			✓

2.2. Scope of the Study

In this study, first of all, biological monitoring and its varieties are discussed and categorized. Biological monitoring has been evaluated in six main categories and the usage areas, advantages and disadvantages of biological monitoring types are presented. In addition, these methods have been applied to the West Marmara Sea coasts.

2.2.1. Ecological

The type of monitoring defined in the water framework directive. This method focuses on community structure changes using indicator organisms sensitive to pollution, and determines these changes by using biotic and diversity indices using macroinvertebrates and other indices using other organisms such as macrophytes and planktons.

2.2.2. Physiological and biochemical

It is based on the responses the metabolisms of organisms give to changes in water quality. Methods such as the growth rate of algae and bacteria and the determination of the oxygen production potential of water using algae are used.

2.2.3. Microbial

Basically, bacterial indicators of faecal contamination such as Escherichia coli and other coliforms are used. Human and animal faecal contamination can be distinguished. It also includes methods such as the typing of bacteria to identify the source of organic pollution.

2.2.4. Bioassay and toxicity tests

It is a method of rapid determination of the acute toxicity of water on the death, growth rate and reproductive capacity of organisms using test organisms.

2.2.5. Chemical analysis of biota

It is known that contaminants such as metals or organic pollutants accumulate in the tissues of organisms. It is the method of determining the levels of pollutants within the organs and body of the organisms that are known to accumulate the pollutants within their body as a result of collecting them from the water in question or exposing them to it

2.2.6. Histological and morphological:

It is a method based on the investigation of the morphological symptoms such as the lesion and tumor produced by the organism in the environment (Bartram and Ballance, 1996).

2.3. Biological Monitoring in Freshwater

The fact that organisms can be easily collected, that they have a cosmopolitan distribution, that their ecological needs are known well, that they accumulate pollutant substances, that they can be produced in laboratory conditions and that their roles in the community are known. Besides all these advantages, biological monitoring has the disadvantage that it requires more expertise than other methods (Bayraktar, 2007).

The physical, chemical and hydromorphological properties of water bodies should also be used as supporting elements of biological quality elements (Schaumburg and Schranz, 2004).

Living things which are the components of the aquatic ecosystem sometimes undergo a change and degradation due to differences in living environments. Pollution creates a decrease in environmental quality. Biological monitoring of water quality means evaluating the biological data collected from the water body in the field and in the laboratory in order to determine whether legal standards and criteria are fulfilled in the aquatic ecosystem (Kazancı and Türkmen, 2008).

Biological monitoring has the disadvantage of requiring more expertise than other methods besides all these advantages (Bayraktar, 2007).

When the reactions of aquatic organisms against changes are determined, the quality of the existing water environment is also determined. Therefore, while planning the quality monitoring studies in a lake or stream, biological parameters should be included as well as chemical parameters (Zeybek, 2007).

2.4. Biological Quality Elements

The necessary conditions and quality elements for the prevention of ecological status in fresh waters are benthic macroinvertebrates, macrophytes, benthic algae, phytoplankton and fish fauna. Biological quality elements and monitoring table are presented in Table 2. Different biological quality elements respond to different pressures and which quality element represents and responds to which pressure and the severity of this reaction are summarized in Table 3.

Table 2. Biological quality elements to be monitored according to WFD

Quality Elements	Rivers	Lakes
Phytoplankton	1,2,3,4	1,2,3,4
Aqua Flora	1,2	1,2
Benthis Macro invertebrates	1,2,5,6	1,2,5,6
Fish	1,2,6,7	1,2,6,7

Notes: 1: taxonomic composition, 2: abundance, 3: biomass, 4: plankton bursts, 5: diversity, 6: precision taxa, 7: age structure

Table 3. The reactions of biological quality elements defined in WFD to different pressures

Biological Quality Elements	Hydromorphological Pressures	Nutrients	Organic Pollution	Acidification
Macro invertebrates	++	++	+++	++
Bentic algae Macrophytes	+	+++	++	++
Fish	+++	+	+	+

3. Tekirdağ and West Marmara Coastline

The most important directive on water quality is the Water Framework Directive. The main objective of the directive is to prevent the deterioration in the status of all superficial water bodies and to achieve “good status” in all water bodies. Definition of swimming water includes basic information about the dispersion and physical environment of swimming water, swimming water limits and the location of the representative monitoring point and administrative sub-units.

The general definition of swimming waters is that it is the body of water in accordance with the regulations and the definition covers neighbouring waters which are affected by the discharges from neighboring waters, urban or rural activities and which may affect the quality of swimming waters. In particular, the determination of swimming water profiles of the project by the coast of Turkey is considered as the basic elements here in this study.

3.1. Effects of Pollution Sources on Swimming Waters

In order to determine the hydrological properties of pollution sources, lands and their usage, population, former water quality data and the possible effects of the existing industry in the area have been evaluated and the study has focused on updating the pollution conditions of swimming waters. In addition, the parameters used in determining swimming water pollution sources and the possible effects of these parameters have been examined.

Firstly, the location, condition, pollution and other effects of the following sources and their effects on the region or their distributed load equilibrium are discussed.

(i). Discharges of secondary residences / summer houses and tourism facilities,

(ii). Wastewater treatment, sewerage infrastructure, and untreated discharges.

(iii). Rainwater discharge,

(iv). Highway surface flows;

(v). Slaughterhouse, fertilizer plants, dairies, etc. and their effects,

(vi). The number of cattle in the pastures and the loads caused by their waste.

(vii). Agricultural areas in the region,

(viii). Risky transports to the coasts via rivers, waterways and canals.

(ix). Sewage sludge (after treatment or treatment)

(x). Personal yachts, boating and commercial boat and ship movements and their pollution (sintine, WC, kitchen waters and other solid wastes),

(xi). Decreases in water quality caused by tourist activities during the summer or during the most crowded periods,

(xii). Pets and bird colonies on the beach,

(xiii). Fauna and flora,

(xiv). Inlets of groundwater; especially in some places it is quite effective.

(xv). Industrial discharges and cooling water discharges,

(xvi). Port activities,

(xvii). The effects of the pollution caused by many pollutants such as fish farms on the current system and the factors that prepare the mathematical analysis have been tried to be put forward.

3.2. Swimming Area Pollution Sources

It was aimed in this study to determine the pollution conditions of swimming waters, to establish emergency response centers, to redefine hot spots and sensitive areas, to determine waste absorption capacity by monitoring modelling methods and to develop sustainable urban wastewater investment plans.

3.3. Measurement Parameters

The measurement parameters Microbiological, Physico-chemical and Biological parameters. These are determined via measurement parameters given below.

(i). Microbiological

Total Coliform

Intestinal enterococcus

Escherichia coli

(ii). Physico-chemical

pH (in situ-CTD)

Dissolved oxygen (in situ-CTD)

Colour (visual)

Mineral oils (analysis if visuals are available)

Surface active agent (analysis if visuals are available)

Phenol (verification that there is no phenol-based odour/ analysis if available)

Visibility (secci disc)

Tar residues, plastic floating materials (visual)

Nutritional ELements (NO3, NH4, PO4)(eutrophication, if available)

(iii). Biological

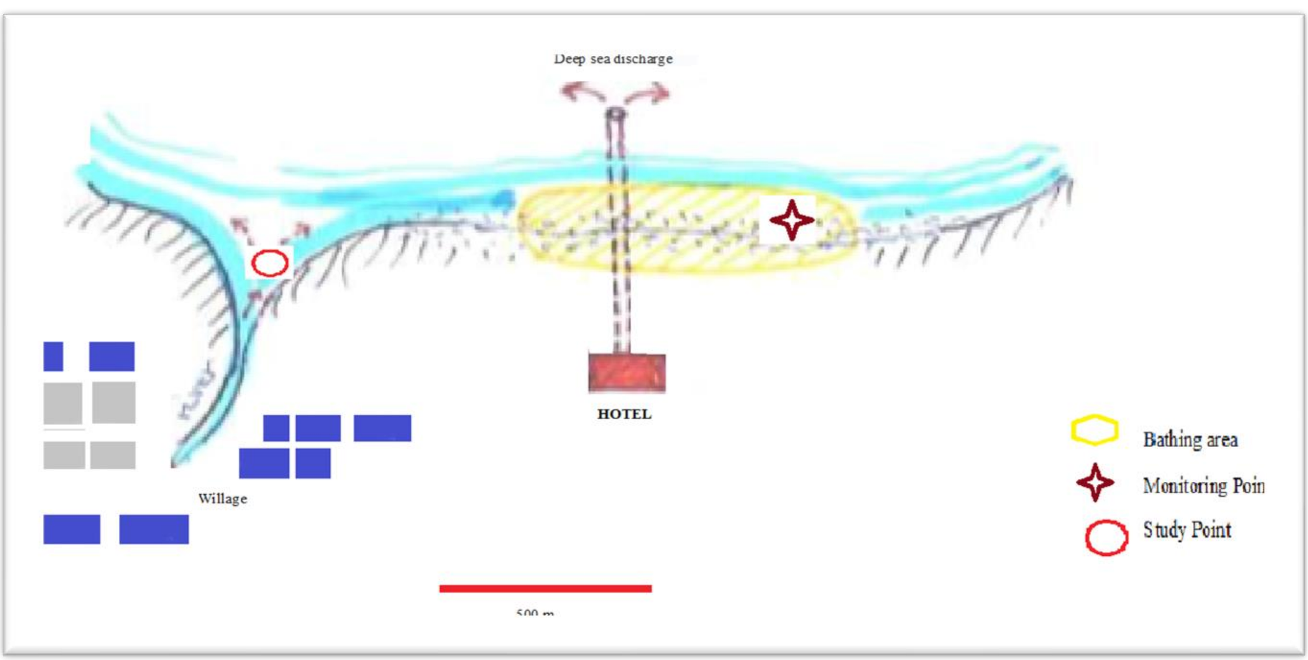
Total phytoplancton

Cyanobacteria (Synechococcus and Prochlororcoccus)

3.4. *Other Sources of Pollution*

It is necessary to determine the stress especially on the swimming areas of coastlines (port, agricultural field, industrial plants, fish farms, etc.), to identify the mouths of rivers or brooks, which are within the swimming areas, to determine specific pollution parameters, to determine chlorophyll-a revealing nitrogen phosphorus, and the increase in the population of phytoplankton for wastewater discharge, and fish farming activities, and PAH for marine activities, refineries, and filling facilities) and to identify specific pollutant parameters according to industries. Thereafter, the assessment of cyanobacteria / algae incidence risk includes the identification of short-term pollution risks (<72 hours).

Figure 1. Determination of Swimming Water Profiles on Coasts



3.5. *Swimming water profile*

The advantage of swimming water profile is that it is important in terms of detected pollution, foreseen risks, and result outputs. In this case, the major issues, being;

(i). The design of management models enabling the prohibition of swimming in hazardous areas,

(ii). Providing the involvement of local authorities and the communities into water quality management process to a great extent,

(iii). Taking precautions for short-term pollution,

(iv). Enhancing water quality,

(v). Protection the health of swimmers effectively, were studied thoroughly.

4. Conclusion and Assessment

As a result of this study, it is concluded that it is essential that the sustainable water usage is provided in order to protect water resources at a long period, the matter discharge is decreased or eliminated, the discharge of primary hazardous matters is prohibited or their use is abolished, the aquatic ecosystems are protected under specific measures, and their development is sustained.

Figure 2. Perspective of a coastline provided for swimming

It is also necessary to prepare water body typology lists of Turkey, to form a monitoring network for the determination of the mass and typology of river boundaries of previously identified 'River Basin'.

It is primarily important to make classifications such as very good/good, and good / moderate class border/limit values, subsequently, moderate / weak and weak / bad class border/limit values for biological quality elements.

It is important to integrate this study into more extensive studies to be conducted in our country, and also to implement a system similar to the Common Implementation Strategy for the Water Framework Directive (2000/60/EC) related to 'The Classification of Ecological Status and Potential' (European Commission, 2003).

It is essential to determine the ecological status of water masses in Turkey using data, developed metrics, and identified class border/ limit values obtained from biological, physico-chemical and hydro-morphological monitoring networks.

The fall of the status of very good / good class water masses should be prevented from losing their quality, whereas the ones with moderate, weak, and bad status should be improved in order to reach good quality in a shortest possible time through the determination of necessary measures and programmes, and their implementation. This should be implemented not only to Istanbul-Tekirdağ shoreline, but also to shorelines all approximately Turkey.

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