 

# Engineering contribution to a water sustainability policy

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ABSTRACT: For both developed and developing countries, the dawn of the 21st Century arose full of environmental problems, which were due primarily to a lack of appreciation, concern and understanding of the causes of environmental pollution. International discussions, aiming at preventing earlier mistakes of developed countries being repeated throughout the rest of the world, resulted in the introduction of the concept of sustainable development. The recognised definition for sustainability in fact implies concern for social equity between and within generations and recognition of both the essential needs and the limitations of technology and social organizations with regard to the ability of the environment to meet present and future demands. The objectives of a sustainable water policy, as defined by the European Commission, are analysed in this paper from the engineering contribution point of view. Although decisions may eventually be made on political or philosophical grounds, it is essential that effective methods in training future engineers be made accessible, along with the available engineering and scientific information, so as to assist decision-makers in this area.

## INTRODUCTION

In working for the essentials of life, sustainable development should involve an integrated manner about relevant economic, environmental and social objectives. Engineering, as a profession, must include environmental protection in its brief if it is to retain public credibility. Engineers can no longer design and construct projects without assessing their impact upon the environment [1]. Engineers work in multidisciplinary teams alongside ecologists, environmentalists, chemists, economists, planners, sociologists and lawyers.

Peavy, Row and Tchobanoglou defined environmental engineering as being:

> *… that branch of engineering that is concerned with protecting the environment from the potentially deleterious effects of human activity, protecting human populations from the effects of adverse environmental factors and improving environmental quality for human health and well being [2].*

Environmental engineering is closely associated with other branches of engineering, eg civil and chemical and with the sciences of chemistry, physics and biology. As such, it may seem like *all things to all men*; from this point of view it is an evolving branch of engineering and this contributes to its excitement as a profession.

Environmental engineering addresses problems in the water, air and soil environments. Some people think that environmental engineering evolved out of sanitary engineering, which is a subset of civil engineering. Civil engineering students have been taught sanitary (public health) for over 100 years. Traditional sanitary engineering addressed problems of water quality (drinking and wastewater) and municipal solid waste disposal.

Civil engineers traditionally covered the areas of hydrology and water quality, water treatment and wastewater treatment. Chemical engineers, on the other hand, identified with chemical processes, industrial wastewater, hazardous waste and air pollution.

Subjects like ecology, microbiology, groundwater, solid waste, farm waste, noise pollution, environmental legislation and management are now considered essential in the education of an environmental engineer.

Engineering education is the most effective means of changing engineering practice in the quest of environmentally sustainable solutions that can achieve both a better management of decreasing environmental resources and the protection of nature [3].

## THE EUROPEAN COMMISSION POLICY

The European Union (EU) has been developing and implementing legislation to protect the aquatic environment for over 30 years. The latest Directive puts in place a management structure so as to ensure that all water quality, including lakes, rivers, groundwater and coastal waters, will be protected and enhanced through proper cooperation and management.

The Water Framework Directive (2000/60/EEC) makes this bold statement at the outset:

> *Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such* [4].

This European Commission defines the objectives of a sustainable water policy as follows:

- Provision of a secure supply of a safe drinking water in sufficient quantity;
- Provision of water resources of sufficient quality and quantity to meet other economic requirements of industry and agriculture;
- Quality and quantity of water resources sufficient to protect and sustain the good ecological state and functioning of the aquatic environment;
- Management of water resources to prevent or reduce the impact of floods and minimise the effects of droughts.

## THE ROLE OF ENGINEERS AND SCIENTISTS

Water engineering is probably the largest single branch of the civil engineering profession. Public works, such as water supply and sewage disposal schemes have traditionally been seen as civil engineering activities. The relation with civil engineering is due to the fact that most water engineering works involve large structures and require a good understanding of hydraulics. Water science and technology typically involve the application of biological, chemical and physical principles along with engineering techniques.

A major objective in the research of water quality control is to reduce the incidence of water-related diseases. This depends on the ability to develop water sources, which provide an ample supply of healthy water, ie water free from the following aspects:

- Visible suspended matter;
- Excessive colour, taste and odour;
- Objectionable dissolved matter;
- Aggressive constituents;
- Bacteria indicative of faecal pollution [5].

Having provided water of suitable quality and quantity by source protection and the appropriate application of treatment processes, it becomes necessary to convey the supply to consumers through a distribution system, consisting of water mains, pumping stations etc. Most of the domestic and industrial uses of water cause deterioration in quality and the wastewater produced must be collected and undergo suitable treatment before it can be released into the environment. In many cases, treated wastewaters provide a large proportion of the water resources for other users.

Water has many uses, so any quality management has to take into account different requirements and constraints. Water quality control measures must balance between the needs of water supply services and effluent discharge requirements. Various factors must also be recognized in a situation where industrial activity and changing agricultural practices can increase urbanization and influence the quality of water.

Big cities produce large volumes of solid wastes, which may, in turn, create major environmental problems with regard to their disposal. Landfills and other solid waste disposal sites may be responsible for water pollution, since rainfall or groundwater can leach highly contaminating substances from the deposited materials. Attention should also be directed towards seeking a reduction of packaging material along with a recovery and re-use of other waste materials. Indeed there is a need of what can be termed *clean technology* [6].

## THE POLLUTION PROBLEM

Environmental protection has, for the last period of at least 50 years, been a major concern in the civilized nations of the world. Initially the concern was limited to public health but has, since the 1970s, been expanded to include the environment. As stewards of our environment, we are responsible for its protection, for our own sakes and for the benefit of generations to follow. It is understood that technology can not continue to advance, ignoring the environmental deterioration that occurs from irresponsible discharge of the waste, which, eventually, comes from technology.

The environment consists of physical, chemical and biological substances that interact so that the physical and chemical substances support the biological and allow them to experience sustainable growth. At the present level of human advancement, humankind is able to influence the balance of these substances, positively or negatively and consequently affect the health of the environment.

The role of the environmental professional is to make design and management decisions in such a way so that they allow the use of the environment without a negative effect. Discharges from human activity are generally released into the air, the water or the soil. Each of these potential reservoirs can accept a limited amount of physical, chemical and biological substances without deterioration. Beyond this point of assimilation, the environment may be deteriorated up to a point where sustainable growth can no longer occur.

The deterioration may be caused by the weather in different forms. Some of these are wind (dust blown in the air), rain (storm water eroding soil into the water and floods depositing solids), lighting (fires discharging smoke and particulates into the air and water along with ash on to the soil), volcanoes (smoke and particulates into the air, water and soil). The above deterioration can also be caused by vegetation (hydrocarbon vapours discharged into the air and dissolved hydrocarbons running into the water), animals (faeces polluting the water) and activities of humans.

The air, as a reservoir, dispersing the pollutants, provides no beneficial treatment to them. This dispersion either dilutes the pollutant to a concentration which is innocuous, or it transfers the pollutant to a downwind location. A factor making the situation difficult is the non-predictable of wind direction and velocity. Air pollution may be significant in the study of water pollution since wastewater may volatilise either deliberately or through evaporation and become air pollution.

Water, as a reservoir, can provide minimal treatment to certain organic pollutants because of the oxygen and biota in the water. Water may also act as a disperser of pollutants. This dispersion is easier to model since it flows in a defined channel with a predictable velocity. Water pollution is usually of regional interest because of this dispersion.

The discharge of pollutants onto or into the soil is normally only of local concern, since liquid migrations in soil is slow. Soil pollution is normally of concern when the pollutant is liquid or is a soluble solid. An insoluble solid will not migrate, nor will it dissolve into the groundwater. The major concern with soil pollution is the subsequent pollution of the groundwater when it is used as a source for drinking, irrigation or industrial use.

CLASSIFICATION OF POLLUTANTS

There are several ways of classifying pollutants in order to predict their effects on water quality and the means of their removal. Firstly, they can be classified as a solid, a liquid or a gas, or as one of these, mixed with or dissolved in another. Secondly, each of these can be organic or inorganic. Organic waste can additionally be classified as volatile or non-volatile, refractory or biodegradable, and of animal, mineral or vegetable origin. Inorganic wastes should be further classified as dissolved, suspended or settle able and by pH, although information needed on a waste includes temperature, volume or quantity. Table 1 shows the various types of waste.

Table 1: Types of waste.

| Basic State | Mixed State | Sub-State | Example |
|---|---|---|---|
| Solid | Solid | Organic | Sugar |
| | | Inorganic | Salt |
| | Solid in liquid | Organic | Food processing waste |
| | | Inorganic | Electroplating waste threat |
| | Solid in Gas | Organic | Plant aerosols |
| | | Inorganic | Incinerator particulates |
| Liquid | Liquid | Organic | Gasoline |
| | | Inorganic | HCl |
| | Liquid in Solid | Organic | Garbage |
| | | Inorganic | Uncured concrete |
| | Liquid in Gas | Organic | Air stripper mist |
| | | Inorganic | Mist |
| Gas | Gas | Organic | Toluene |
| | | Inorganic | Air |
| | Gas in Solid | Organic | Floats |
| | | Inorganic | Methane storage tank |
| | Gas in Liquid | Organic | Anaerobic decomposition |
| | | Inorganic | Dissolved sir flotation |

The above general characteristics must be determined before understanding the effect of the pollutant on the environment and determining the sampling, analytical or treatment method. In order to select a treatment system to reduce or remove pollutants, the classification of the pollutants is of greater interest than the source or legal category. If the waste is from a municipal, industrial or landfill source, or is toxic or hazardous, then it is of less interest than its characteristics. In the treatment process, there is more interest in the physical, chemical and organic characteristics of the waste.

The reason for which a solid waste may be considered as hazardous is that pollutants can be leached out of the waste by groundwater and stormwater, percolating through the soil and pollute the underlying groundwater. If the solid waste were fixed, there would be no leaching, and consequently no pollution. Therefore the critical nature of solid waste is its liquid leaching, which means that, apart from its handling and storage on the land, solid waste treatment is identical to waste water treatment in concept and theory.

Before a treatment system is selected to remove pollutants, some parameters must be additionally established, including geographical, financial and political factors. Geographically, the area available for the appropriate treatment needs to be addressed. Financial factors would include the budget for the project in terms of both cost and time, while political considerations would comprise zoning, permit availability, community support and future regulatory legislation.

THE SITUATION IN GREECE AND THESSALY

The European Parliament has verified the following:

> *The state-members, have, up to a large degree, unfortunately, failed to fulfil the target of the directive concerning the nitrate pollution, namely the decrease of nitrate pollution of waters, warding off the eutrophication problem and the subsequent low quality of potable water, along with the consequences on the health of humans and animals.*

It is marked, specifically for Greece, that there is a large delay in instituting the necessary measures of implementation of the corresponding directive, despite the fact that the state-member had admitted the existence of eutrophication problems in some bays [7].

In fact, today, in the greater Thessaly area (see Figure 1), there are locally some regions facing serious problems from nitrates. It was reported last summer that the nitrate concentration in a specific local region was 81.5 mg/l. Of course, there is always a risk for more regions to face the same problem, especially since the phenomenon is not *static*, ie the problem does not recognise borders between different regions.


Figure 1: Map of Greece showing Thessaly.

Other local problems in the greater Thessaly area include the following:

- The use of pesticides in the form of sprays polluting mainly surface waters.
- The lowering of the water table due to excessive pumping.

- Unrestrained dumping of rubbish on a landfill. Although in cities of more than 10,000 inhabitants there are strictly defined places as landfills, in small villages, there is always the risk of a free dumping, which may lead to local soil pollution with the subsequent pollution of the groundwater.

CONCLUSIONS

In the 21st Century, water might cause crises similar to the oil crises of the 20th Century and most possibly, these water crises may be more violent. After all, there is no substitute for water as it is a direct requirement for the survival of both human beings and other life on earth [8]. It is worth mentioning here Gandhi's saying: *There is enough for everyone's need. There is never enough for everyone's greed.*

Two distinct directions of education in either the local or national level have to be implemented and taken into account. They concern training for farmers and environmental engineers.

From the farmers' point of view, some basic principals might be helpful to be pointed out:

- Farmers have to be properly informed and consulted regarding problems that include the excessive and non-rational use of the fertilizers and pesticides, and their subsequent impact upon the environment.
- The Government has to provide motivation for a transfer to a biological cultivation. This might be the best solution for the nitrate problem, not only due to the lack of the use of fertilizers, but also because biological products are healthier than the corresponding conventional produce.
- A potential tax increase on fertilizers by authorities would most possibly lead to a more prudent use of nitrates, with a consequent reduction of nitrate pollution.
- The strict application of an agricultural code of practice by farmers would result in the proper storage of fertilizers, a rational and correct use, with specific doses for defined cultivations, for the appropriate time of fertilization.
- The direct pollution of water masses has to be avoided. In such a case, the local authorities have to be immediately informed to take precautionary measures. Clear water is necessary for living organisms.

From the engineering point of view it would be essential if effective methods in training of future engineers would be developed. A start for these methods could well be teaching in the secondary education of subjects relevant to environmental pollution and how the human health is affected. A second step could be a television or newspaper campaign.

Finally, in the local universities or Technological Educational Institutes (TEI), the incorporation of various technological subjects of environmental antipollution in the curricula could make a substantial contribution. On top of this, the available engineering and scientific information collected from different fora might prove to be a powerful tool in assisting decision-makers to amend or complete existing legislation.

Apart from the above, in regions with low population, the creation of water quality control centres, which test chemically and microbiologically the waters of the local area, could guarantee a safe level of quality potable water, providing a healthy life for humans.

In closing this paper, it is worth noting a phrase written in a memorandum with aspects for water: *Just think of what the future is going to be, taking into account that the fish, being unable to live on the ground, has already started to die into the water*.

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