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## Biological Approach for Recycling Waste Water in Iraq

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**ABSTRACT:** The middle and southern parts of Iraq are exposed to a series of serious drought-related problems. This is mainly linked to the absence of applied international law for water distribution in the Euphrates and Tigris rivers between Turkey, Syria, and Iraq, in addition to climate change and unawareness of the water resource problems for more than three decades. The Inter-Agency Information and Analysis Unit of the United Nations reported that water in the Tigris and Euphrates will decrease by up to 80% and 50%, respectively, by 2025. Therefore, water recycling would be an essential and inevitable sustainable approach under these circumstances. The biological treatment of sewage, industrial waste water, scientific laboratories effluent, and irrigation waters using compact units is described here to be involved in solving the water shortage in Iraq. The main indicators used to assess the efficiency of these units are chemical oxygen demand (COD), biological oxygen demand (BOD), total solved salts (TSS), and total fecal coliforms (TFC). These units have been approved to treat contaminated waters with 10-fold pollutants in a fifth of the time required as compared to other classical procedures. In conclusion, using these treatment units will be useful in tackling the problem of water shortage in Iraq and could potentially be the best control method to stop the spread of infectious diseases obtained from contaminated waters.

**KEYWORDS:** industrial waste water, biological treatment, pollution control, water recycling

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## Introduction

Iraq faces a crisis of severe drought particularly in its middle and southern regions. This is the consequence of three decades of war and neglect affecting the environment and natural water resources, thus making it difficult to provide safe drinking or irrigation water for the majority of Iraq's 33 million population by the year 2015.<sup>1,2</sup>

Furthermore, in 2010, the United Nations reported that 63% of urban houses and 98% of sub-urban houses were in serious need of safe drinking water.<sup>3,4</sup>

The Tigris and Euphrates rivers, both originating in Turkey, are the sources for 98% of surface water in Iraq. Both of them pass through long distances in Turkey and/or Syria before arriving in Iraqi territory. The geographical situation and the atmospheric conditions related to rainfall levels as

well as the volatility of the political situation are all influencing the amount of water reaching Iraq, causing large annual fluctuations.<sup>5</sup>

These barriers will affect the environmental, economic, agricultural, and health developments in Iraq. One major issue is the large number of dams that have been built in Turkey on the Euphrates and Tigris, at an approximate cost of 32 billion US dollars.<sup>6</sup> The latest dam built on the Euphrates is called the Ataturk Dam and is 80 km from the Syrian borders.<sup>7</sup> Collectively, these dams were designed to stop 500 billion cubic meters/second of water, equivalent to approximately half of the original capacity of two rivers, flowing through Iraq.<sup>3</sup> Syria and Iraq, which are downstream of the Euphrates and Tigris sources in Turkey, have an agreement to divide water downstream of Turkey, with 42% for Syria and



58% for Iraq.<sup>6</sup> Hence, a water research institute consisting of 18 water experts from each country to study the issues of the water in the Euphrates river has been established.<sup>6</sup>

The United Nation Information Agency is expecting significant decrease in the water levels of both the Tigris and the Euphrates reaching Iraqi territory by the year 2025<sup>3</sup> from 49.2 billion cubic meters/second (the level of 2009) to 9.1 billion cubic meters/second. On the other hand, the Euphrates river will lose about 50% of its water during the same period, from 19.34 billion cubic meters/second to 8.45 cubic meters/second.

These major challenges of water scarcity require a coordinated and concentrated strategy developed by several key governmental institutions including the ministries of higher education, health, agriculture, industry, and environment in co-operation with local governmental organizations. Strategies that need to be considered to address the current and future problems will be considered in this review article.

**Waste waters in Iraq.** Waste waters in Iraq from agricultural farms, power stations, industrial factories, oil refineries, and research or hospital laboratories are currently a huge source of pollution to the already stretched drinking water systems of Iraq.<sup>8</sup> However, if utilized appropriately, they can become a major potential resource. These waste waters contain a large number of biological and chemical pollutants that are hazardous and have a serious impact on human health.<sup>9-13</sup> Therefore, recycling techniques need to be developed that have the ability to remove these pollutants or reduce their level to an acceptable national/international standard as been adopted in 1970s where about 95% of the urban population and 75% of rural population gained safe potable water.<sup>14</sup>

The World Health Organization reports confirm that drinking and irrigation water in Iraq is of a very poor quality.<sup>8</sup> The biological and chemical contaminants contained in the drinking water caused the incidence of 360,000 gastrointestinal infections during the first half of 2010. Moreover, the high salinity of surface waters (5000 parts per million) made these waters unsuitable for crop irrigation.<sup>14</sup> Thus, any strategic plan should consider addressing the current deficiencies in the drinking and agricultural water supplies.

**Determining the sources of water pollution in Iraq.** The first and most important step of any strategic plan should be to collect reliable data on the types and levels of all the pollutants in the waste and drinking waters. This important scientific task must be fulfilled as soon as possible using rigorous and reliable scientific protocols. A systematic study of current industrial and agricultural waste waters should establish the level of biological pollutants, chemical pollutants, and agricultural contaminants such as insecticides and fungicides. Many of these pollutants may be carcinogenic and/or teratogenic and mutagenic, and the extent of these potential effects on human health needs to be quantified using established biological methods such as short-term bioassays using bacteria as bio-indicators.<sup>15,16</sup>

Animal carcinogenicity tests often take a significantly longer time and have a greater cost compared to bacterial bioassays. In addition, animal tests can only identify a very limited number of carcinogenic contaminants.<sup>17,18</sup> As an example, the determination of the carcinogenic potential of a single chemical using laboratory animals may take more than 3 years and can cost up to 250 million Iraqi Dinars (200,000 US dollars).<sup>15</sup> Animal testing to determine the hundreds or thousands of potential environmental contaminants would be unfeasible, especially considering the urgency of the problems faced by Iraq. Therefore, efficient short-term biological assays using internationally certified methods to predict the environmental carcinogens as mutagens in bacterial strains should be the main technique employed for generating these data.<sup>15-18</sup>

Here we must point out that the Ames test could be an ideal method; it has been used since the seventies and is still used in most parts of the world for predicting environmental carcinogens through the use of *Salmonella* strains that are specifically designed to detect multiple genetic mutations.<sup>18-20</sup> This relies on the specific design of a *Salmonella* strain that requires the amino acid histidine in its growth culture.<sup>18</sup>

This method has been implemented to examine more than 300 chemical substances known to be carcinogenic to mammalian cells and is established through thousands of research protocols conducted over four decades. The reported data show that about 90% of these carcinogens are mutagenic in *Salmonella*.<sup>17-21</sup> For the remaining 10%, the fluctuation test that exposes bacteria to chemicals in a special aqueous solution or after the addition of a rat liver enzyme (S-9 enzymes) is also a useful assay.<sup>21-24</sup>

The reported literature has described three axes for the screening of environmental carcinogens/mutagens in an aquatic environment:

1. Analyzing the chemical elements in the water and identifying all its chemical components, then systematically testing each one for its mutagenicity and/or carcinogenicity. This task is usually labor-intensive and time consuming because of the large number of water chemical constituents.
2. Concentrating chemical components of the water and assessing the impact of the concentrate using short-term bioassays.<sup>25,26</sup> This method achieved great results in identifying the net toxicity of substances in an environment. However, the toxicity of some constituents may block the influence of other mutagenic materials in the mixture.<sup>25</sup>
3. Scanning an aquaculture in the aquatic environment for the presence of known mutagenic substances known to be carcinogenic or those that are known to cause birth defects. This method utilizes samples of living tissues from aquatic organisms such as fish, shellfish, or algae and examines them using the Ames test. This method continues to be widely adopted in a number of academic and governmental organizations because this approach

provides information regarding individual known carcinogens but can be utilized in a high-throughput system.<sup>27–30</sup>

This method can also be used to differentiate between pesticides harmful to human health and other safe contaminants. For example, this approach has also been used for the first time in the province of Kerbala, Iraq, to determine the length of stay of pesticides in some largely consumed vegetables such as cucumbers and tomatoes.<sup>31</sup> In general, this technique can be considered as fast, cheap, and reliable to achieve a database of all the chemical pollutants that cause genetic mutations or cancer in the aquatic environment, as well as for identifying their input sources and to control their spread through aquatic environments.<sup>29</sup> This can be done through coordination between members of the chemical analysis research team and biologists using the short-term bioassays.<sup>28</sup> Building up such a database of carcinogens would be an important resource both for Iraq and for the scientific community.

**Pathogenic bacteria in water.** Many types of microbes, especially pathogenic bacteria and viruses, are polluting the aquatic environments of Iraq leading to widespread public health problems. These microbial pollutants can arise from food factories, hospitals, university laboratories, and scientific research centers.<sup>31,32</sup> This is particularly a problem in the most rural areas where the population often drink water without chlorine disinfection.<sup>32,33</sup> One of the most serious problems resulting from microbial pollution of drinking water supplies is the spread of antibiotic-resistant bacteria in the drinking water resources<sup>34–36</sup> Polluted waste waters are lacking the necessary treatments in most Iraqi cities and villages and contribute to the issue of pathogen contamination of water systems. 63% of residential houses in Iraqi cities and 98% of residential houses in rural Iraqi villages lack disinfected water for drinking (Water Supply and Sanitation—Wikipedia, 2012).<sup>4</sup> For instance, in Sulaymaniyah province in 2010, more than 1500 cases of cholera infection as well as 2000 cases of hepatitis viral infection were reported, and in eastern Baghdad's Sadr city, more than 360,000 cases of intestinal dysentery were reported in relation to the contamination of drinking water with sewage.<sup>3</sup> These issues require quick and firm decisions in order to stop the threat to public health and halt the spread of diseases.<sup>37–42</sup>

A database of microbial contamination in the surface waters of the Iraqi environment needs to be created. This can then be used for the introduction of the latest scientific techniques such as diagnostics indicators of microbial contamination, which causes intestinal epidemics especially cholera, *Salmonella*, *Shigella*, and viral hepatitis.<sup>32,34,35,39,42</sup>

However, it is very important to take into consideration that there may be some cases of antibiotic-resistant bacteria in the drinking or recreation waters that may cause human diseases. This will also greatly aid in identifying the sources of pollution and dangerous pathogenic bacteria, in addition to the public health in a research environment.<sup>29,34,36,38,40,41,43,44</sup>

**A local based approach for waste water treatment at source.** Many technical procedures can be used for waste water treatment. One approach depends on small-scale biological treatment and filtering units that minimize environmental effects. These may be a useful way to implement waste water recycling at source before it enters the water systems at a relatively low cost. The main advantages of this technique are as follows:

- Treating sewage and heavily polluted industrial waters with high efficiency.
- Purifying water as it emerges from industrial sources and controlling pH and oil derivative levels and providing a local source of water to be used in agriculture.

Sterilizing water by UV, which does not adversely affect the environment.

We propose the following standards as a minimum baseline:

Biological Oxygen Demand = 10 parts per million (ppm)  
Total Solved Salts = 10 mg/L  
Chemical Oxygen Demand = 38 ppm  
Total Fecal Coliform = 0–2/100 mL  
Oil & Grease = 0

These small-scale fully automated systems with automatic sludge separation can be purchased commercially and delivered pre-assembled. The basic design of such units would include:

- Main bio-reactor tank with three chambers, epoxy coated
- AMB Bio Media™ Proprietary Media 950 m<sup>2</sup>/m<sup>3</sup>
- SS coarse air distribution systems with butterfly valves, coarse air, no clogging, EEC design
- Non-return valves (check valves)
- Necessary cables and accessories
- Tube settler
- UV sterilizer
- Pressure sand filter
- Rotary displacement blower
- Submersible feed pump with cutter
- Displacement sludge/recycling pump
- EEC automatic sludge separator
- Necessary PVC piping and valves
- Motor control panel

These processing units are the optimal way to treat contaminated water and use it to irrigate crops and public parks and at a relatively low cost. Compared to classical methods, the development of mobile bio-film expands the surface area of the biological treatment up to 950 square meters per cubic meter.

## Conclusion

It is very clear that Iraq could be facing a serious problem of drought in the coming years. Therefore, a national strategic plan must be implemented soon to take appropriate decisions





**Figure 1.** Examples of fixed EEC High-Speed Bio Tec – 120 m<sup>3</sup>/day treatment plants.

and address the critical problems associated with existing water pollution caused by industrial contamination.

The first step toward a solution requires the establishment of advanced scientific centers at each Iraqi university, using established, reproducible techniques to generate a reliable database of the pollutants and pathogens contaminating the water systems so that the challenges can be met with an informed and methodical approach. This would also allow the setting of drinking water quality standards across Iraq.

We propose an approach for tackling the waste water pollution problems using technologies to recycle the waste waters and utilizing them for the irrigation of crops. This approach would have the benefit of preserving fresh water supplies for drinking and reducing the amount of pollution entering the fresh water system. Treating waste water using small-scale units at major pollution sources can be implemented in a rapid and cost-effective way.

### Author Contributions

Conceived and designed the experiments: MAJA-M. Analyzed the data: MAJA-M. Wrote the first draft of the manuscript: MAJA-M. Made critical revisions: MAJA-M. The author reviewed and approved of the final manuscript.

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