

## **Evaluating and Developing of Water Resources Quality Monitoring Program Implemented by Environmental Ministry- Iraq**

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**Abstract:-** Evaluating effectiveness of monitoring program is important element in reviewing loop to improve program performance and program development. In this study, the water resource monitoring program implemented by ministry of environment have been evaluated to address strengths and weakness points. Program has evaluated against monitoring objectives, monitoring parameters, regulatory compliance, data product, and institutional and human competence. Evolving monitoring program has been required to overcome some hampered such as unclear objectives, limited parameters, Lacks in quality control procedures and quality assurance procedures, absence of data analysis and management, and shortage of specialized expertise. The program have many of the strengths factors that can be built on such as it have institutional structure and good hierarchy, the human resources, a lot of equipment and laboratory facilities with good capabilities, accumulated experience, historical data on general water quality parameters which gives an overview of the pollution sources and water quality. It's important to develop water resources monitoring program in the light of the national strategy of environment adopted by ministry of environment and based on principle concepts and approaches such as integrated water resource quality management, design on catchment context, inclusion of biotic indicator, aquatic ecological health approach, and data product to support decision making.

**Keywords:** evaluation, monitoring program, parameters, water resource, water quality, water management.

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### **I. INTRODUCTION**

In Iraq, water resources face a number of problems and challenges which affect water quality and quantity like riverheads locations outside Iraq; riparian countries monopolizing water without any relevant agreements or conventions; deteriorated water quality as a result of incorrect practices and lack of efficient water treatment systems; and lack of integrated water resources management accompanied by an increased water demand due to population growth, climate change, industrial needs and the Marshland recovery needs (1).

Water quality monitoring program is a critical step but it is only one of several other equally critical steps in the water resources management process. The ultimate goal of monitoring is to provide the information needed to planning, decision-making and operational water management (2). Modernization water quality policies and programs are required to prevent institutional and policy failure.

Monitoring is not only important due to the legislative requirement to assess standards for mandatory environmental policy, it is also vital as it enables detection of the presence and extent of underlying changes in water quality. Water quality measurements provide essential data and knowledge to, evaluate the condition and functions of aquatic ecosystems, including spatial patterns and temporal trends; evaluate the influences and impacts of human activities, and the risks to human and ecosystem health; support planning initiatives, decision-support tools; measure environmental performance and support the development of water polices and management practices (3).

Because of the need to crucial information on water resource quality to support decision making and effective water management purposes, there is a need to evaluate water monitoring program implemented by ministry of environment to insure it is meeting information needs while operating in an efficient manner. The administration of program should evaluate its overall monitoring program as part of a continuous improvement and development. This paper aim to evaluate the effectiveness of water resources monitoring program which is key element to improve performance and efficiency, and evaluate it against the objectives to determine whether progress is being made, and whether the selected indicators are appropriate measures.

## **II. WATER QUALITY MONITORING PROGRAM**

Water monitoring is the systematic collection and evaluation of data about the chemical, physical, and biological quality of the water resources, and assesses how external changes, both natural and anthropogenic, affect that quality(1).

Water quality monitoring and assessment can be conducted according to different perspectives such as specific regulatory statutes, Water resource protection and Environmental management and policy support which may combine to achieve the goals in different ways (3).

Components for effective monitoring program were summarized by (Lovett et al, 2007) as:

- Design the program around clear and compelling objectives and base the setup on scientific principles.
- Include review, feedback, and adaptation in the design.
- Choose measurements carefully and with the future in mind.
- Maintain quality and consistency of the data.
- Plan for long-term data accessibility and sample archiving.
- Continually examine, interpret, and present the monitoring data.
- Include monitoring within an integrated program..

The design of a monitoring program should be based on clear and well thought out aims and objectives and should ensure, as far as possible, that the planned monitoring activities are practicable and that the objectives of the program will be met (7).

## **III. OVERVIEW OF EXISTING MONITORING PROGRAM**

The structure and hierarchy of water monitoring program are consists of the administration represented by department of water quality control at technical directorate, technical sections at regional directorate of environmental protection and improvement, water control division at each province environmental directorate and local laboratories at each province environmental directorate and central laboratory at central region directorate of environmental protection and improvement. Water monitoring program cover ambient surface water resources which have been monitored through over 140 locations (monitoring stations) across the country. About 60 monitoring station are spread along the stream of Tigris and Euphrates rivers which are represents the main water resources in Iraq. Another 80 monitoring stations are cover the other water resources such as Sub rivers, tributaries, canals, lakes and marshes. It is worth mentioning that the monitoring program covers the water-course without taking the catchment context in consideration. Water are principle sampling media used for current water monitoring program.

Water samples are collected manually at a rate of two frequencies per month from each station. water sampling operation include collect samples manually from each station, field measurement of some variables, pre-treatment and conservation, identification and shipment. Samples are collected by staff of water control divisions staff at province directorate. These samples are analyzed in the same province directorate laboratory, in addition the central laboratory which used to analyze another samples for specific task in deferent intervals as well as intersection samples. About fourteen water quality parameters are monitored monthly, which include general parameters (e.g. pH, DO, temp., TDS, Ec, and Alk.), simple cations and anions (e.g. Ca, Mg, K, Na, SO<sub>4</sub> and Cl) , and nutrients (e.g. PO<sub>4</sub>,NO<sub>3</sub>).

Data of water quality parameters collected by activities of monitoring program at provinces environmental directorate and the central laboratory are documented on a monthly basis and send to monitoring program administration. The administration of monitoring program which represented by department of water quality control in the technical directorate at environmental ministry are compile the collected data received in an unorganized Microsoft excel sheet where data are subject to a preliminary assessment and verification.

## **IV. RESULTS AND DISCUSSIONS (EVALUATION OF MONITORING PROGRAM)**

Clearly, a need exists for comprehensive and accurate assessment of water quality that raise awareness of the urgent need to address the consequences of present and future threats of contamination and to provide a basis for action at all levels. Good planning of monitoring is essential for data collections to be cost-effective and relevant to help achieving the water quality objectives. Current monitoring program should consider the catchment context rather than water course to integrate water quality management. A catchment area, and its associated watercourse, is hydrologically and ecologically discrete and, therefore, constitutes a logical unit for the planning and management for the monitoring of water quality (7).

### **4.1- Monitoring objective**

Evaluation the effectiveness of monitoring program should focus on a variety of desired outcomes that parallel strategic objectives. Identifying a clear purpose for monitoring is the first and most critical step for an effective monitoring program and should be based on an analysis of issues affecting the water resources (8). The

monitoring objectives should clearly related to management decision making to obtain the desired information. water quality monitoring program is effective only when it meet the information needs of water resource quality managers.

In the current water quality monitoring program implemented by MoE, there is no clear and comprehensive water quality monitoring strategy establishes specific goals and objectives. Lack of strategic planning, absence the concepts of integrated management, restricted financial resources and untrained human resources which were accompanied the creation of the program causes significant weakness in the design of the monitoring program which been reflected largely on outputs.

The national strategy for Iraq and its action plan within the second strategic objective (protecting and improving water quality), have been identified issues and problems facing Iraq's water resources. Issues and components contained in the second strategic objective of the national strategy (water protection and improvement) could be adopted as one of the solid foundation in the development of monitoring program by identifying clear goals and specific objectives. The various causes and origins of the deterioration of water quality have been require tailor-made approaches and solutions for the effective monitoring, management and improvement of the quality of water resources (9).

#### **4.2- Selection of monitoring site and monitoring parameters**

Monitoring program need to be responsive to local hydrology, climate and landscape (10). Selection of the monitoring sites (stations)of current program are taking into consideration the point of joining water body, withdrawal water, major point sources, and non point sources to show the difference between upstream and downstream water quality. Through the distribution of monitoring stations that have been existed, it's clear that the program are serve to determine the temporal and spatial trends of water quality, determining pollution sources and estimate the effect of discharged load.

Another important consideration in water quality monitoring program design is the selection of appropriate parameters (indicators) for water quality testing. Water quality parameters selection is very important and depends on several factors, which are ultimately driven by the overall purpose of the monitoring program (8).

The parameters measured by existing monitoring program implemented by MoE are include Common parameters measured in the field such as dissolved oxygen, conductivity, pH, and temperature. Also include common parameters which measured in the laboratory such as nutrients ( $PO_4$  and  $NO_3$ ) and simple cations and anions (e.g. Na, Ca, k, Mg,  $SO_4$  and Cl). These parameters determine the stability and chemical forms of water (11). These are generally considered routine measurements in most investigations. It is generally well accepted that these measures alone cannot provide sufficient information to assess water quality and cannot ensure the protection of biodiversity and the maintenance of essential ecological processes.

In according with the national strategy, which identified a number of issues and components related to the protection and improvement of water resources quality, the current monitoring program is not sufficient to give adequate assessment of the water resources quality. Parameters such as biological indicators, sediments, toxic elements, pesticides, and specific organic compounds should be monitored in specific stations at specific intervals as necessary for water assessment. These parameters could be performed and represents a new initiative to develop monitoring program depending on specific objectives.

Recent approaches to the assessment of water resources have adopted a hydrogeomorphic perspective, which emphasizes that the interaction between the flow of water and channel form is key to river condition (12, 13). As well as the use of biotic indicators has become a core component of aquatic ecosystem health assessment (14). Biota integrate the effects of multiple stressors in space and time (15) and thus provide a way of detecting stressors that may be so variable in time (e.g. pulses of metal effluent associated with storms) or space (e.g. bank erosion) that they are neither logistically nor economically feasible to monitor directly. In this regard it's important for the administration of program to pay attention toward the concept of ecologically sustainable development which provides a comprehensive philosophical umbrella under which could pursue the issue of water quality management.

#### **4.3- legislation framework and Regulatory compliance**

The law of environmental protection and improvement (EPI) no 3 in 1997 which replaced by law of (EPI) no.27 in 2009 in section 2 article 14 and the regulation no.2/2001 (preservation of water resources) are provide the framework for the protection of water resources from pollution and improve its quality. Regulation no.2/2002 setting standards for minimum water quality requirements in physical and chemical term for established typology of water resources and set maximum allowed pollutants concentration for wastewater discharged to water resources. About 33 water quality parameters for four type of water resources have been identified with the standards while wastewater discharged have been established with standards for about 45

parameters. The variables identified in standards for water source and discharged water included physical variables, cations and anions, some toxic chemical, and heavy metals, without any biological variables.

The most basic scientific and policy task of water management programs is to agree on what distinguishes “good” (acceptable) from “bad” (unacceptable) conditions. Standards are usually established narratively as well as numerically for particular water body types (e.g., rivers, lakes, wetlands), and ultimately for specific water bodies. One of the important elements of monitoring program are collecting and analyzing information on the compliance status of the regulation. Monitoring are essential to detect violations, provide evidence to support enforcement actions and evaluate program progress by establishing compliance status. It is noteworthy that most of the parameters set forth in the water resources standards are not measured in the current monitoring program activities. Thus monitoring program seem inefficient from the viewpoint of determining compliance with regulatory except in a narrow area.

#### **4.4- Data management and reporting**

A comprehensive and complete data reporting is useful and helpful for further data processing. In many cases inadequate data reporting lead to wrong or inaccurate conclusion. Effective synthesising and summarising of collected data is a fundamental requirement for assessing and communicating water quality information. An essential element of monitoring and assessment is to inform those responsible for policy and management so they can respond and address emerging issues. Reliable monitoring data are the indispensable basis for such assessments (16).

There are substantial amounts of data, available on water quality resulted from the monitoring of measured parameters of surface water quality along the Tigris, Euphrates, Shatt al-Arab and rivers accompanying tributaries and water sheds, from more than 140 monitoring stations, over the past years. The status of water quality data is a serious issue especially as these should form the basis for national action programs on water quality management. Usually the selection of water quality parameters are insufficient, the data are often not quality controlled or quality assured and may be unreliable, the data are not evaluated nor converted into data products that can be used for decision making. However, the use of this data is hampered by the lack of statistical and quantitative analysis, which would show correlation, trends, and causative relationships to major pollution sources (17). Developing database, statistical tools and methods for data gathering, reporting and analyzing can improve and elaborate the existing system and help to provide more accurate and reliable data and assists finding the answers of the questions related to the water resource quality.

#### **4.5- Institutional coordination and human resources competence**

Water management is a shared activity. The MoE capabilities for developing water resources monitoring are restricted by current funding levels, staff, training, laboratory resources and upcoming improvements. In this area a partnership-monitoring framework could be advantageous. MoE should be coordinated and cooperated in a complementary manner with involved entities (such as other state ministries, organizations, local governments, universities, industry, environmental groups, and citizen volunteers) in order to build comprehensive monitoring program as a part of integrated water management system.

Suitable institutional arrangements at the national and local levels are necessary for monitoring and assessment of water resources quality. Within any river catchment or water body, by coordinating and cooperating with other entities, MoE can develop a coherent, well-planned approach makes for more scientific and cost-effectiveness monitoring efforts (accomplish intended goal, eliminate duplication of monitoring efforts and deliver more data in the same financial resources). For example, MoE can cooperated with ministry of water resources (which also have monitoring program) by dividing monitoring efforts to eliminate duplication. MoE should concern on chemical and biological parameters, while hydrological and geomorphological parameters could be monitored by ministry of water resources. The responsibility for groundwater monitoring and assessment with regard to water quality and quantity may lie with the general authority of groundwater. Assessment of water resources also requires socio-economic data, including population and economic statistics, which are collected by Central Statistical organization. In many instances, it is necessary to seek expertise from research institutions, universities or the private sector. Dividing of tasks between the different entities is necessary to reduce the costs and efforts.

The management cycle that is integral to water quality monitoring and reporting requires well documented and clear procedures for measurement, quality assurance and review. This requires the necessary infrastructure to collect and process data, and effective management and professional capacity of human resources. Hence, all stages of the process from monitoring design to review of reported results rely on professional capacity and the enabling environment to develop skills and competencies. Reduced human capacity is a frequent restriction to effective water management. To achieve and develop competent human

resources requires appropriate recruitment and training procedures, and the professional environment for human capacity to act, reflect and adapt (18).

## V. CONCLUSIONS

In general, the current water monitoring program has many strength factors, in the same time has many weakness points. Strength factors can be summarized such as it have institutional structure and good hierarchy, the human resources, a lot of equipment and laboratory facilities with good capabilities, accumulated experience, historical data on general water quality parameters, and gives an overview of the pollution sources and water quality.

On the other side, the current water monitoring program has significant dysfunctional such as lack of strategic view and planning, not clear objectives and goals, limited measured parameters, Lacks in documentation procedures, quality control procedures and quality assurance procedures, absence of data analysis and management, and shortage of specialized expertise. In other words, developing current monitoring program have been required to provide sufficient information to assess water quality and support decision making as part of water quality management.

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