Marine Environment Monitoring System for Kuwaiti Water Territories

Naser Zaeri[1]
Electrical Engineering Department
College of Engineering and Petroleum
Kuwait University
zaery@eng.kuniv.edu.kw

Abstract

In January 2005, the State of Kuwait has launched one of the most advanced and sophisticated environmental projects in the Middle-East to monitor its water territories. This leading project, which is funded by the Environment Public Authority, is considered the main building block for a huge integrated system to monitor the environmental status for the whole area of Kuwait. The advanced system consists of a number of buoys integrated with the state-of-the-art suite of sensors that measure a number of important biological and chemical parameters in water. These parameters are crucial to monitor if someone is seeking to inspect the oil pollution, Industrial pollution, Organic pollution, and Sewage and Wastewater. Finally, this system enhances the capability in predicting any abnormal or undesired event that may affect the eco-system of the State of Kuwait.

Keywords – wireless communication system, buoys, suite of sensors, environmental monitoring

1. Introduction

The state of Kuwait has suffered serious marine and air environmental damage in recent years caused by many factors such as the ballast discharge of passing commercial vessels, the hazards waste discharge by industrial coastal plants, frequent oil-spill accidents, and the catastrophe of the oil well fires during the Iraqi invasion of Kuwait. In addition, the rapid pace of industrialization and residential development of the coastal areas in Kuwait is causing an alarming increase in industrial and domestic wastewater and sewage discharges into the sea. Another factor that is contributing to the ecosystem damage in Kuwait is the fact that the Gulf has a very narrow access (Straits of Hormuz) to the Arabian Sea and the Indian Ocean. Such tight access prevents the natural process of seawater exchange and purification/dilution of the embayed pollutants.

The Environment Public Authority (EPA) is the leading institution in charge of monitoring and protecting the Kuwaiti environment. The role of the EPA is: a) to ensure that the quality of the environment, in terms of the level of pollutants and toxins in the ecosystem, conforms to the international environmental/safety standards and b) to enact counter measures and solutions if otherwise. To achieve this goal the EPA must continuously monitor the levels of a large number of pollutants and environmental parameters in all the land and sea territories of the State of Kuwait. As such, the EPA has recently implemented an efficient, accurate, fast, robust, cost-effective, and state-of-the-art environmental monitoring and data collection/analysis system. This huge oceanographic buoy system is a complete end-to-end, interactive gulf-observing system, with two-way communication for telemetry and commanding via cellular telephony network. The monitoring system gives the capability to increase the knowledge of the gulf variability and its connection with large-scale weather systems and climate change, and posses the ability to retrieve large amounts of data in real-enough time, coupled with interactive data platforms. Another important advantage of this system is its contribution to the sustainable development of marine resources, the protection of the marine environment in the State of Kuwait, through improved weather and marine resource predictions, based on the provision of additional monitoring, analysis and prediction. Moreover, it acts to strengthen marine meteorological

[1] This project was designed by the author and was implemented under his supervision and consultancy.

activities of relevant institutions, authorities and environmental departments in State of Kuwait.

2. Motivations beyond Implementing the New System

Although the EPA's utilizes some of the most advanced monitoring equipments, the old systems have few drawbacks. The main drawbacks are: 1) the monitoring system covers only limited parts of the Kuwaiti environment, 2) limited monitoring of industrial plants, and 3) it depends, in most parts, on the manual collection and processing of environmental data. For example, for the case of marine monitoring, the EPA employs few research boats that periodically collect and test samples of seawater. However, such technique is painfully slow and inadequate due to:

- The large size of the targeted sea area and small number of samples (i.e., *limited spatial sampling*)
- The small frequency of samples (i.e., *limited temporal sampling*)

More importantly, this process suffers from two other serious limitations:

1) Slow *response time* to any abnormal changes in the environment.
2) Limited *prediction* capabilities of the future occurrence of any abnormal environmental phenomena.

The red tide event (in 1999) and mass fish kill phenomena (in 2001) have clearly demonstrated those limitations. The new implemented monitoring system addresses all the limitations *economically* and *reliably*.

3. Project Strategies and Implementation Arrangement

Recent technological developments have made possible new approaches to monitoring including buoys and remote sensing to measure wind stress, sea surface height, and ocean color in real time, and assimilation of these data into global and regional models for general marine products. We have made extensive studies for around two years to find out the most suitable and efficient method to implement the project. The different studies covered many issues, of these:

1. Kuwaiti marine conditions
2. Climate and Atmospheric conditions
3. Chemical parameters affecting the marine life
4. Biological life
5. Wireless communication coverage area
6. Market analysis and equipments availability

The studies aimed mainly to measure the following sources of pollution:

(i) Oil pollution
(ii) Industrial pollution
(iii) Sewage and Wastewater
(iv) Organic pollution: it is attributable to excessive input of organic water and/or nutrients.
(v) Thermal pollution: caused by heat energy discharged by power plants or factory cooling water.

The great capability of the system will ensure to take a fast and wise action enough to prevent problems caused by those sources of pollution, enhance the marine meteorological observing system through the upgrading of old equipment and installation of new observing systems, and to take advantage of recent development in *in-situ* marine observing technologies.

4. System Description

4.1. Oceanographic Buoy System

The system consists of several large buoys that have the capability to monitor the gulf environment, Fig. 1. The system is designed to absorb repeated collisions and abrasion.

Figure 1.Example of the buoy system deployed in the Kuwaiti water territories.

Each buoy consists of multi sensors, full onboard processing data unit, two-way communication link for data transfer and remote control of buoys, and a special mooring design that minimizes mooring influence on buoy motions.

The electronics well houses batteries, the data system and interface electronics, and the radio electronics. Access to the electronics well is through a hinged lid. Waterproof bulkhead connectors around the top of the well connect external devices to internal electronics.

The instrument box supports the structure of:

1) Solar panels
2) Batteries
3) Meteorological sensors
4) Radar reflector
5) Guard light
6) GPS antenna
7) Radio antennas
8) Data storage and processing system

4.2. Data processing unit (Data logger)

Data processing unit is easily utilized in a way that the data can be added to a database accessible through the Internet, accommodates all standard interfaces so that any desired sensor can be quickly added, and posses a large hard disk. Moreover, it is able to do the major statistics (average, normalize, filter, compress, etc.). It is capable to remotely collect, process, and transmit data derived from multiple sensors. Fig. 2 shows the data processing unit and how it interacts with the different parts of the system.

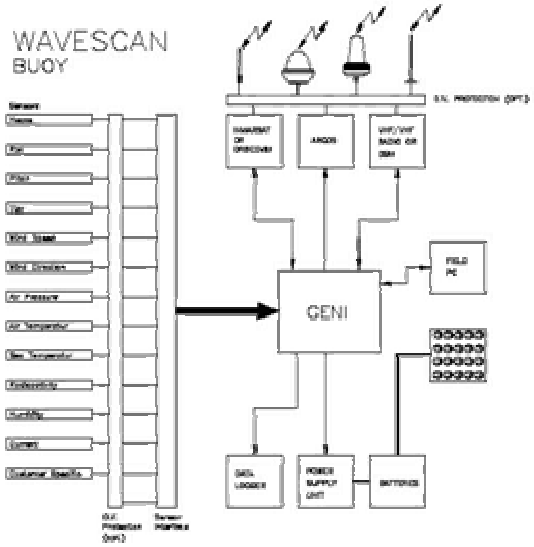

Figure 2.Data processing unit and its interaction with different parts of the system.

4.3. Data communication method

Data communication method is based on mobile transmission system using cellular telephony network. It is has the ability to retrieve large amounts of data within minimum time of its being collected, coupled with the ability to send commands to the data platform. In addition, it allows sending commands to the buoy in case of failure recovery or dynamic response to interesting phenomena. The system comprises a GSM mobile radio network provided by the mobile telecommunication companies in Kuwait. The SIM card is used as an interface. Data is transmitted according to system configuration where the buoy has configurable transmitting and receiving intervals. An illustration of the communication system used is shown in Fig. 3.

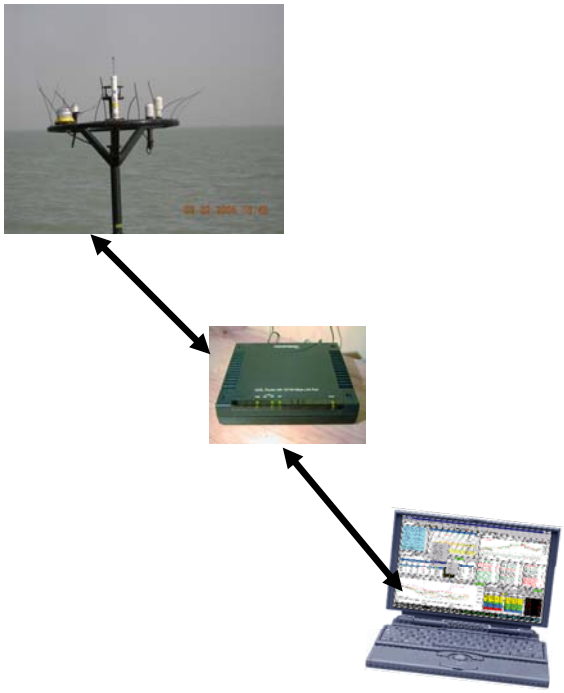

Figure 3. Illustration of the data communication system used.

4.4. Power system

The power system of the buoy system consists of three parts:

1. *Power Management Unit (PMU)*: controls the charging and discharging of the batteries, supervises the battery voltage and switches to back-up source or disconnects the load if necessary. Moreover, it distributes power to the different users. In addition, it is able to provide power system status information to the data logger.
2. *Solar panels*: main power supply for the buoys.
3. *System of long duration batteries*: charged by the solar panels through a regulator.

The reason behind using two independent power systems is to add a good level of reliability.

4.5. Sensors

A full package of remote sensors that provides accurate and precise measurements is used. This full suite of meteorological and oceanographic sensors is compatible with surface and subsurface of the buoy. These sensors measure the following parameters:

1. Wind speed
2. Wind direction
3. Atmospheric temperature
4. Relative humidity
5. Pressure
6. Oil spill
7. Dissolved Oxygen
8. Current Direction
9. Current Velocity
10. Chlorophyll
11. Solar Radiation
12. Water temperature
13. Salinity (Conductivity)
14. PH
15. Heave
16. Turbidity
17. Algae bloom
18. Heavy Metals
19. Nutrient concentrations

4.6. Software

The data acquisition and command/control software performs many tasks: Data formatting and archiving, Position/time updating, Networking / communications (telnet, FTP, and e-mail), displays multiple raw data graphs as a function of time, displays multiple engineering graphs as a function of time, and finally it can show statistics graphs, with standard deviation, max, min, and arithmetic mean value calculations.

5. Buoys Locations

The system consists of eight buoys distributed all over the Kuwaiti territories water as explained below:

- East Bobian Island
- East AlBeda'
- Kuwait Bay
  - North-East Mina AlAhmadi
  - South-East Mina Abdallah
  - South-West Qarouh Island
  - North-East Kubbar Island
  - North Failakah Island

Figure 4. The State of Kuwait Map with the locations of the buoys shown.

6. Future Goals

One of the future goals of this project is to expand the overall marine meteorological monitoring network to cover the entire State of Kuwait. Another important goal is the integration of the system with other regional systems. Sustained, routine and long-term measurements and monitoring of marine environmental variables would be promoted using conventional and new observing techniques. An infrastructure for servicing and repairing instruments, data quality assurance and data storage would be established.

7. Conclusion

The fast pace of urbanization, the increased population, the activities of oil refineries and the dumping of wastewater into the sea are direct sources of the waste management problems and sea pollution problems in Kuwait. The new project develops and implements comprehensive marine environment assessment methods to employ biotic, chemical, metrological, and oceanographically indicators, and to strengthen marine environment surveys and monitoring activities. The system is aimed to preserve the ecosystem, minimize marine pollution, and protect the biological community.

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