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24/24 Smart Stations for Pollution Monitoring Sea Coast or Artificial River

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24/24 المحطات الذكية لمراقبة تلوث مياه البحر أو النهر الصناعي

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Abstract

This is a new applied engineering study for the possibility to monitor huge distances of the sea coast, or artificial river collecting water nodes against pollution in water quality by measuring network with a biological early warning system, it is a continuous and automated sea/water quality monitoring and thus makes an important contribution to the early detection of disasters or accidents as well as to the evaluation of hazard potentials. This system is used for efficient control of automated sea/water quality, and continuous sea/water quality monitoring for twenty-four hours' analysis using smart stations connected over a wireless computer network instead of the old method of sample collection and then lab. Analysis. The functionality of the 100% web-based multi-tier system comprises workflows for automatic sampling and quality assurance, the administration and control of equipment in the measuring stations, numerous options for data evaluation, illustration, and export as well as a notification system.

Keywords*: Smart sensor, Pollution, Data network.*

الملخص

تهدف هذه الورقة العلمية الهندسية إلى تصميم نظام ذكي بإنذار مبكر لمراقبة مسافات طويلة من شط البحر أو النهر لكوارث التلوث الذي قد تحدث في أي لحظة، وذلك عن طريق وضع محطات مجسّات ذكية ومتباعدة مرتبطة بحواسيب لمعالجة البيانات المقروءة، مرتبطة بقاعدة بيانات رئيسية مرتبطة عن بعد لتحليل هذه المياه بشكل دائم خلال اليوم وكل يوم. إنه نظام يقوم بإعطاء إنذار مبكر على المحطة التي سجلت قراءات تفوق المعدل الطبيعي للتلوث. هذا النظام يستخدم بيئة الإنترنت كوسيلة لنقل البيانات التي يتم تسجيلها في المحطات، واستخدام نظام الإنترنت الفضائي للمحطات الموجودة في الأماكن النائية من ناحية أخرى، والسحب الذاتي للعينة، تحليلها، تطبيق نظام الجودة، إرسالها النتيجة للجهات المخولة، وإصدار الإنذار الرقمي عن طريق البريد الإلكتروني أو الرسالة القصيرة لجهاز الهاتف النقال للمحطة الرئيسية.

الكلمات الدلالية: الحساسات الذكية، التلوث، شبكات محوسبة.

1. Introduction

Water pollution is one of the major threats for the green globalization, to overcome the water pollution, first is to detect the pollutant either in river water or sea coast. The classic way to detect the water pollution is by using laboratory test, and by using this laboratory system (Karl and Willig, 2007). The samples should be given to testing equipment operator, then

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technical report are generated for that sample only and for that period of time of sample collection.

The new technique of testing, is to place probes and data acquisition channel in the river water or sea to detect pollution remotely by using different wireless sensors connected to server on site to monitor physical or environmental conditions, such as temperature, pH, conductivity, and heavy metals. This new technology system is an efficient as technical and practical point of view, since it works with alarm thresholds signal generation, it allows the early identification of critical water input data, and continuous automated water quality monitoring over twenty-four hours daily of ten minutes' idle time of sample collection and result generation

2. Materials and Methods

The designed system is a mix of different high technology equipment's; it works together as one unit or as standalone unit to monitor water activities either as drinkable water resources or sea water resource. The type of sensors of course different in both cases, and each type of sensor and attached station is dedicated to certain task or tasks of monitoring. The system is composed of sensors dedicated for water monitoring parameters such as pH, Oxygen level, temperature, Daphnia and Algae toximeter, data acquisition channel for data handling and process, computer system with specific technical specifications, wireless data network for connecting slave station to the host, and main file server which connects all remote stations by Local Area Network (LAN), or Wide Area Network (WAN). The complexity of the system is mainly dependent on number of parameters to be monitored during twenty-four hours daily, and number of stations used to monitor, for example a coast. The benefits of this system that no laboratory operator is required to collect a sample, then analyze it in special laboratory located a way from sample picking place. All the process done automatically by auto sampler, where analysis and result are generated on the site, then transmitted to the next server towards the main sever to give an alarm either by Mobile Text Short Message (SMS) to supervisor of the system, or technical report showing threshold values limits reached.

2.1. Materials

The materials used in the design of this system are a set of detectors (bio monitors), dedicated computer with touch screen, servers, data acquisition channels, local and wide area network either wire or wireless connection.

Various sensor combined in dense sensor network to monitor pH, Oxygen level, temperature, Daphnia and Algae toximeters, and fish toximeter.

2.1.1. Daphnia Toximeter

These daphnia or fish toximeters are sensitive to detect toxic substances in water via computer assisted digital image analysis. The system observes daphnia commonly known as

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"water fleas" in drinkable water, or fish in salty water (like sea water) under the influence of constantly running sample water, and to detect hazardous compounds in water from rivers (source-water protection) or sea (Martinez *et al.*, 2004). Plants, distribution systems and production drains to preserve human health and to monitor water as shown in Figure (1).

Figure 1. Daphnia Toximeter station

2.1.2. Algae Toximeter

It is online Biomonitoring using Green Algae, it is fast and sensitive detection of toxic substances in water. The Algae Toximeter continuously monitors water for the presence of toxic substances. Standardized algae are mixed with the sample water and the instrument detects the photosynthetic activity of the algae (Martinez *et al.*, 2004). Damage to the algae, caused e.g. by herbicides, causes a reduction in algae activity and activates an alarm above a pre-defined threshold, as shown in Figure (2). The measurement procedure requires the water samples be almost continually pumped into the Algae Toximeter, in which the concentration and the activity of the naturally occurring algae are determined. A precisely defined amount of algae from the fermenter is then added to the measuring chamber by way of a loop. The activity of the added algae remains constant as long as no toxic substances are present. If any toxic substance is present, its interaction with the photosynthesis center leads to an inhibition of algal activity. The dimensions of the inhibition can be estimated by comparing the algal activity with and without water sample (Mainwaring *et al*., 2002).

2.1.3. Servers and Local Computers

It consists of three major components: System site, System server, and System Client. The first one located at the site of measurement, while the second is to collect data in database

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from sensor resources, and the last is the way to view data and result of different locations in one monitor. All the hardware technical specifications of these system is showed in Table (1).

Figure 2. Algae Toximeter station

Table 1. Recommended system Computer Hardware specifications

Type	Hardware requirement (minimum)	Software requirement
System Server	• e.g. Intel Xeon Dual core processor • 8 *GB* RAM • > 3*GB* HDD + 80*GB* for S/W • 1x*GBit* NIC • 1xUSB 2.0	• Windows Server 64/128 *bit* • Oracle *dB* • NET Framework
System Site	• e.g. Intel Core 2 Duo processor • 2 *GB* RAM • >80 *GB* HDD • 1x100 *Mbit* NIC (for internet access) • 1xUSB 2.0 • Interfaces for device connections (e.g. RS232, Ethernet, RS485)	• Windows based • NET Framework • OPC server
System Client	• e.g. x86 processor 2 GHz • > 512 *MB* RAM • > 300 *GB* HDD • 1x100 *Mbit* NIC	• Windows based • NET Framework

2.1.4. Local and Wide Network

The local network that connects system site to server in short distance by 100 *Mbps* speed of connection, and by using modem or wireless connection if the biosensor is a way from system site. The web based protocol is cloud that connects all the system, also the possibility to use Global System for Mobile (GSM) to connect remote stations to main server to send alarms or short status report.

2.2 Methods

The design of the system is divided to three main categories, the first one is system site which includes the Biosesnsors with data acquisition channel, and computer system which continuously collects data, status messages, and error reporter from the installed measuring systems in the measuring stations. The data records are buffered on the computers and are then transmitted via the Internet to system server as shown in Figure (3). The system server receives data and status messages from all measuring stations, then collected, and stored in an Oracle database. The system server automatically evaluates incoming data if the alarm index points to a suspicious water condition, then the responsible users are informed automatically by SMS and email. The system client displays transmitted data, evaluates and validate, then transmitted via the modem, and with little effort the client can be configured in such a that user can obtain the measured value of all measure and necessary for an assessment of water quality within shortest possible period of time, and generating graphical representation report as shown in Figure (4).

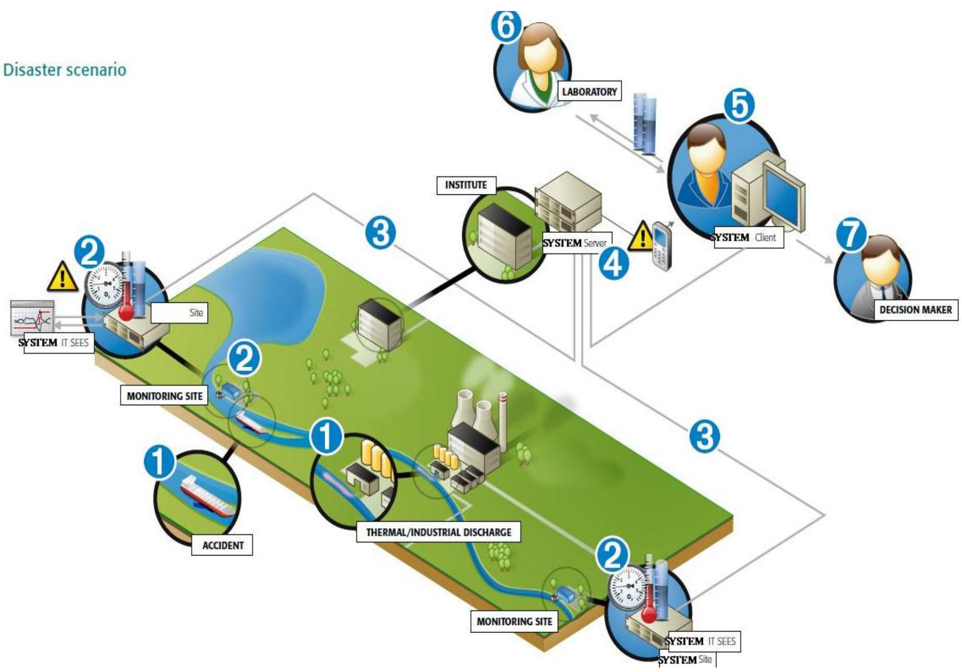

Figure 3. Overall system diagram of System site, Server site, and Client site with data flow direction

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Sample water (0.5 - 2 *l/h*) continuously runs through the measuring chamber containing the daphnia or fish. The live images obtained using a CCD-camera are evaluated online with an integrated PC to analyze changes in the behavior of the daphnia/fish. If the change is statistically significant, an alarm is triggered. The method of image analysis enables a series of measurement methods and plausibility tests to assess the daphnia's/fish behavior using different criteria (Akyildiz *et al.*, 2005).

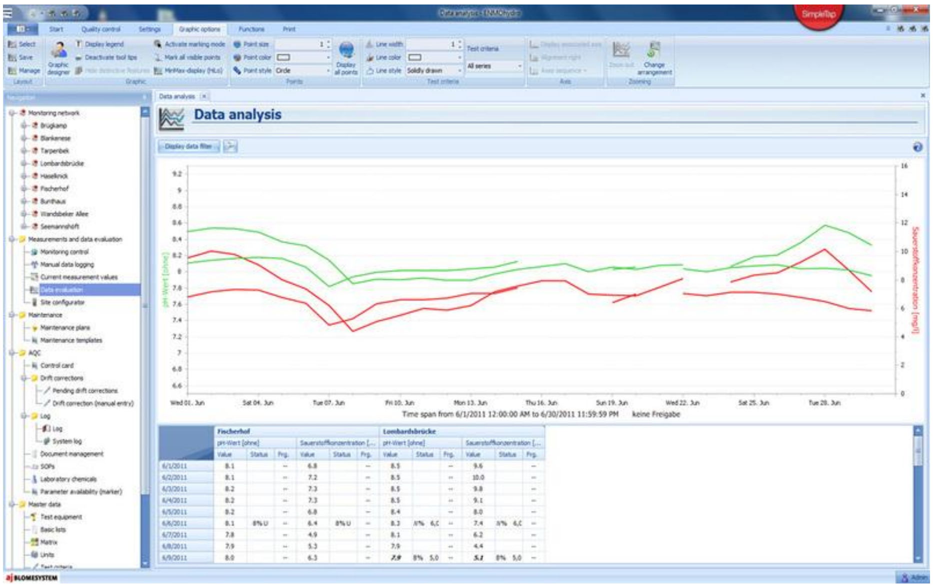

Figure 4. Sample of online graphical representation of Toxicity index value fluctuation

Toxicity index is major concept of evaluation of certain measures, such as speed or height, and changes in these measurements. Only when 2 or more of the measurements simultaneously show unusual results within a fixed period of time, Daphnia/fish Toxic data trigger an alarm. Toxicity detection due to video analysis of daphnia/fish behavior, and measurement is by using video image analysis, and sample volume of 200 *l/hr*, while the sensitivity to toxin is shown in Table (2), with regard to the following: average swim speed, speed distribution, swim height, average distance, fractal dimension of paths, curviness, turns, number of daphnia/fish, distribution in chamber, and size of daphnia/fish.

Table 2. Sensitivity to toxins in Daphnia & Fish toximeter station

Sensitivity to toxins		
Substance	**EC50 in (μg/l)**	**Daphnia Toximeter alarm at (μg/l)**
Aldrin	28	27
Carbaryl	19	22
Chlorpyrifos	344	15
Cyclosarin (GF)	60	10
Cypermethrin	1.2	1
Dichlorvos	170	0.5
Dimethoat	1900	2100
Endosulfan	200 – 900	100
Lindane	800 – 6500	30
Malathion	54	10
Parathionethyl	8.5	10
Sarin	10	6.4
Tabun	30	36
Terbuthylazin	3400	250
Trichlorfon	80	2

2.2.1. Flow of Work Processing

The flow of work processing of designed system is as follow:

1. Toxic substance is emitted into river or sea coast for example after disaster at tanker, chemical factory, or something else.
2. The system site reads the value and transmits them to system IT (Information Technology), then alarm index "warning" or "announcement stage" is created.
3. Values and alarm index are transmitted via internet to system server.
4. System server evaluates alarm index as significant. The administrator user is notified by SMS and email. Automatic sampling in the measuring station stores the suspected sample.
5. The user analyses the values and alarm index via system client to ensure that with utmost probability a non-natural event has occurred (Ma *et al*., 2008). The user then obtains the samples from measuring station and initiates an analysis in the laboratory.
6. The laboratory delivers an analysis of the samples.
7. The user immediately informs the authority responsible for the warning and alarm plan.

The Laboratory Information Management System (LIMS**)** as shown in Figure (5) is the backbone of networking, data management and processing. It is a high-performance, immediately ready to operate laboratory information management system, and able to process the entire range of daily laboratory tasks efficiently and reliably from different resources and converting it to graphical presentation.

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The networking of system clients works on TCP/IP (Transmission Control Block-Internet Packet) protocol, and connected to system server with attached Oracle data base server, and the system protected by firewall for security reason towards system clients. The system site always located a way from the system server and it is connected over internet as data backbone, as shown in Figure (6).

3. Result

Actually this is study is a plane for a new monitoring method of pollution using smart sensors engineering design and still not applied in Libyan environment, but as engineering point of view works perfectly.

This system design is practical and novel, and could be applied also to monitor water resources for other interested parameters also, and this is the main advantages of using it:

- Twenty-four hours' parameters monitoring.
- Multi-level of warning starting from administrator to user.
- No sample collecting and shipping to the laboratory.

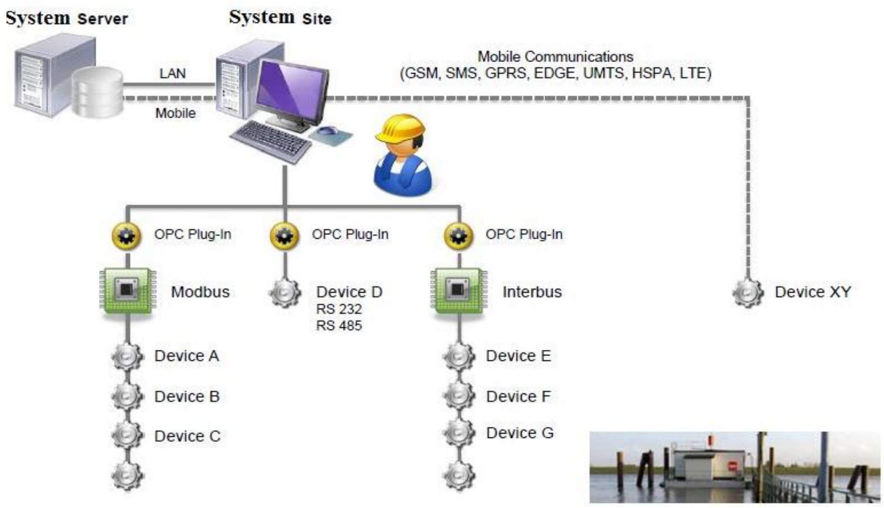

Figure 5. System connection structure using LIMS (Lab. Information Management System)

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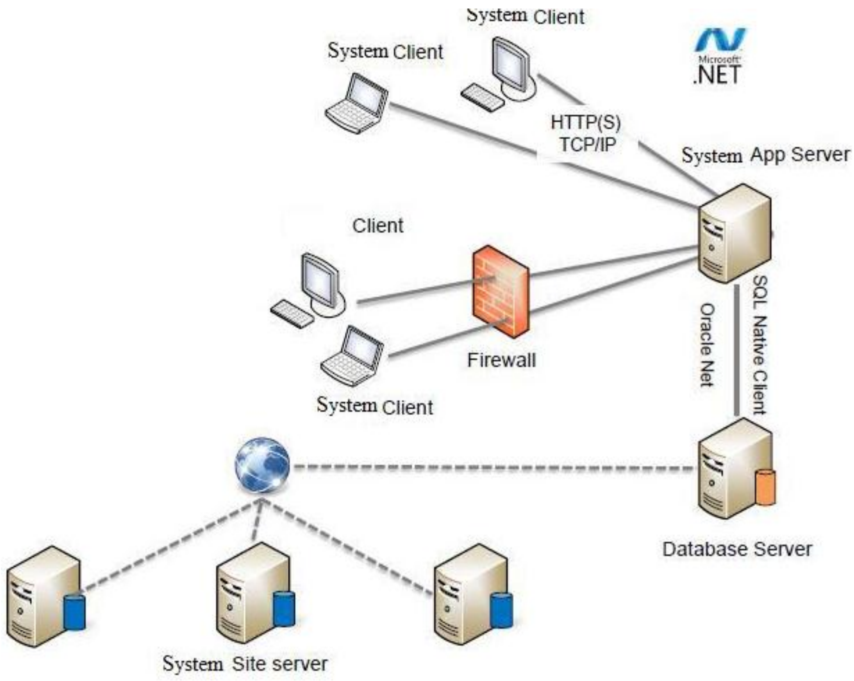

Figure 6. Data Communication networking of System Client, System Server, System Site

- No contamination of collected sample.
- Fast warning if one parameter or more exceed the threshold value.
- Good archiving of data over all sites, and for a long time using LIMS.
- Huge data base storage of sensors reading for process.
- Fast report delivery time from site to server, and then to client.
- Graphical evaluation of sensors data output.
- No consumables.

A technical comparison is done to compare the different smart sensor platform with respect of accuracy, measurement technique, orgasm used in measurement, and application as shown in Table (3).

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Table 3. Toximeter Comparison of different Toxisensors used

	Daphnia Toximeter	Fish Toximeter	ToxProtect64	Algae Toximeter
Organisms				
Type of organisms	daphnia	fish	fish	algae
Number of organisms	10	up to 10	up to 20	algae solution from the internal fermenter
Measurements				
Principle	video/image analysis	video/image analysis	78 light barriers	fluorescence
Versions	1 or 2 chamber version			
Measurands	10 behaviour measurands: - speed - swimming height - size - number of daphnids - speed class index - hight class index - width class index - distance - speed variation	10 behaviour measurands: - speed - swimming height - size - number of fish - speed class index - hight class index - width class index - distance - speed variation	3 behaviour measurands: - activity - fish at the surface - escape reaction	photosynthetic activity: Genty parameter
Groups of especially high sensitivites	pesticides, neurotoxins, respiratory toxins	pesticides, neurotoxins, respiratory toxins	pesticides, neurotoxins, respiratory toxins	herbicides, AOX, PAH
Application	- drinking water - process water - raw water	- drinking water - process water - raw water	- drinking water	- drinking water - process water - raw water,

4. Discussion and Conclusion

This system design is practical and novel, and could be applied also to monitor water resources for other interested parameters also the may affect the environment.

The conclusion is that this system is hybrid system because it is combination of different high technologies like Computer, data communication, Laboratory Information Management System (LMS), Biology, Digital image processing, security and alarming. The system is very effective and practical as long as there are good data communication backbone. The system could be upgraded to monitor air, and to monitor water if there are nuclear pollution, or any other interested parameter as shown in Figure (7).

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Figure 7. Smart sensors stations distribution for pollution monitoring on coast, and main tanks of artificial river

The packets of data sent from system site to server are limited, and all graphical presentation done at server or client system, this will let the system speedy and effective.

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