# Traditional vs. Technological Based Surveillance on Construction Site: A Review

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**Keywords:** Surveillance; Environmental Quality Monitoring; Inspection; Wireless Sensor Network.

**Abstract** The negative impacts of construction activities can be controlled and reduced through identification of environmental aspects and impacts of construction activities, implementation of the mitigation measures and site monitoring on a regular basis e.g through surveillance in the framework of the Environmental Management System (EMS). Continuous improvement efforts towards traditional methods and increased needs for factual information and productivity in the environmental monitoring field have been met with latest innovations in mobile information and sensory technology options. This paper through literature aims to review the traditional and technology based surveillance on construction site. Conclusions are drawn about how those methods complement each other and create the possible implementation of emerging mobile information technologies for environmental surveillance at the construction sites.

## Introduction

The construction activities often have significant impacts on the environment in term of energy and resource consumption, waste generation, pollution and damages of biodiversity and natural habitat. Those adverse impacts had led to a growing realisation that there is a need for the implementation of environmental surveillance within an environmental management system (EMS) framework as an initial step moving towards environment-friendly practices.

In dealing with these negative impacts, environmental professionals confront issues on a daily basis that require prompt, decisive notification, communication and response. Environmental surveillance requires accurate information associated with unique locations in space and time to be delivered to the right person, at the right time, and at the right place. Subsequently by using that information, the immediate sound decision and reaction are to be made by the right person in the same manner.

## Surveillance

Merriam-Webster Online Dictionary defines "surveillance" as a "close watch kept over someone or something" whereas Jenness, Smith et al. [1] and Chen, Chen et al. [2] gives more detail definition. They define surveillance as the process of collecting the information through watching, monitoring, recording, and processing the behaviour of people, objects and events of interested targets in the sensing environment in order to govern activity". In addition, there is the definition of surveillance in associates with the techniques. Tasaki, Kawahata et al. [3] describes that surveillance can be done through routine physical inspection or patrolling, and/or through an established multi-media network on and around the surveillance's area. Similarly, according to Kirchner [4] defines the surveillance as an organised assessment of aerospace, surface, or subsurface areas, places, persons, or things by "observation", technological devices or other means.

**Traditional Surveillance**

Observation is regarded as “physical surveillance” [4] and many (such as the public) would also view observation as an ‘inspection’ as meaning some form of site visit by the inspector [5]. The physical surveillance or inspection is well acknowledged as the backbone of most enforcement programs in the field of environmental management [6-7] and it is widely use to increase the compliance of environmental regulations [8-9]. It is a systematic and deliberate inspection of a person by any means on a continuing basis or acquisition of a non-public communication by a person not a party thereto or visibly presents threat through any means not involving electronic surveillance.

**Traditional Surveillance Method**

With regards to the physical surveillance, the inspector is to carry out routine physical inspection or patrolling, and/or performs assessment through an established multi-media network on and around the site [3]. They therefore will inspect and assess the condition of the mitigation measures installed on site while collecting and analysing documentation, gather the evidence (photographs, samples, etc.) and record observations about the behaviour and position of interested environmental aspects within the surveillance area. The inspector then organises those observations, evidence and supporting documentation into a report for review against standards set forth in law. In addition, their activities would also include, but are not limited to: observing and documenting observations; sampling, measuring, and photographing; coring, drilling, and excavating; reviewing and copying records; and seizing equipment, products, materials, or records [6].

The inspector needs a tool to facilitate them in performing the inspection. European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL)[10] has recommended the checklist and other inspection tools to be used as one of the inspection tools. Most of the inspection tools, especially checklist are mainly in the form of paper, a form still commonly used in today’s construction industry. In consequence, the inspector has to carry all those paper-based documents to the site, whether as references or writing materials during the site inspection. Thus, the inspector has to record the data collected on site by using the paper-based checklist and rely on paper-based reports, plans and etc. as a source of information. The inspector would also has to take a photograph using the conventional camera as an evidence to support his findings. However, it is important to note that these documents are difficult to carry in big quantities and offers very limited source of information at a particular time [11]. Most importantly, due to its nature it is often unable to react to a rapidly changing context and fails to demonstrate the interrelationship between the activities and their consequences in timely manner. The physical surveillance however has a limitation in term of describing the physical, chemical, and biological characteristics of air, water, soil, and other factors. And, that is the reason why there is a need for environmental monitoring (measurement) in any EMS.

**Environmental Quality Monitoring (Measurement)**

Traditionally, for any environmental quality monitoring, monitoring stations will be located and decision on the variables and sampling frequencies will be made at the beginning stage. Sampling exercise then will be executed once all those issues been resolved. Sampling is done by using monitoring equipment devices (typically electrical). This monitoring equipment, then will convert any measured nonelectrical quantity, such as water level, into an electrical quantity that can be stored and processed for measurement of various parameters. In ordinary monitoring at the construction site, field information has so far been acquired by collecting data periodically through the collection of physical samples and/or installation of a data logger at the sampling field while the observation is being supported by the checklist and layout plan in hardcopy format. Subsequently, the physical samples will undergo the laboratory analysis and/or the sampled data in the data logger will be uploaded into the system by using the diskette or any other temporary data storage devices before the analysis to be carried out. The information derived from the analysis, then will be disseminated through a hardcopy report to the respective parties.

Traditional laboratory analysis is sophisticated and sensitive, but is often inconvenient for field use because of the need to transport samples to the laboratory and await determination of results [12]. The travelling time will be very long and there will be a possibility of late arrival at the laboratory that already closed [13]. Moreover, the laboratory process is well proven as time consuming. For instance, the water quality monitoring for the parameters of Total Suspended Solid (TSS) and Dissolved Oxygen (DO) normally took 5-7 working days to complete. In addition to that, previous researches have agreed that although traditional environmental quality monitoring is robust, it is certainly are challenging, labor-intensive, susceptible to georeferencing errors and exposed to deficiencies and discrepancies [14-15].

**Technological Surveillance**

The ability to identify the potential environmental impacts as early as possible is vital to a project of any size and scale because ‘‘prevention is always better than cure’’[16]. As there are many disadvantages were found in the traditional physical inspection and environmental monitoring (measurement), technological based surveillance has become an alternative. Martinez, Hart et al.[17] suggested that the development of environmental monitoring applications need to leverage the technology of Wireless Sensors Network (WSN) which consists of the use of sensors, communication, and computer technologies with knowledge about the environment. It is because, in contrast to the traditional method, the use of mobile devices and real-time data streaming through the Web has the potential to enhance the information management and communication processes among participants and play an important role in field data acquisition and validation, to detecting the potential environmental impacts [18] and more importantly, to provide a warning sign to the areas of construction activities that require immediate corrective action [16].

Previous researches have shown that Information Communication Technology (ICT) and mobile computing can improve the delivery of communication among the construction personnel [19-23]. The environmental professionals can easily carry the mobile devices with wireless communication connection to the field locations for their data collection and validation tasks [24]. They can easily retrieve data and information from the web servers and/or performing real-time data updates, exchanging data between those servers and receiving a warning sign alert from the environmental sensor at their mobile devices if any, simultaneously. This definitely would enhance the delivery of environmental information in construction, and that they are a pathway to improved performance and strategic competitiveness.

Sensory technology on the other hand, has provide a system’s ability to quantify and represent the information about the physical, chemical, and biological characteristics of a certain monitoring parameters as same as what we achieved by using the traditional environmental monitoring before. The development of the wireless sensor network is to collaborate in detection, processing and transmitting the object monitoring information within the network’s coverage areas.

This network contains a large number of static or mobile sensors nodes and a designated sink point (gateway). The sensors nodes are small but have powerful devices that detects or senses a signal or physical condition and later perform simple computations to convert the sensed data into an electrical quantity that can be stored and processed, or directly responds to a physical parameter for the purpose of measurement of a physical quantity or for information transfer [25]. The usual hardware components of a sensor node include a radio transceiver, an embedded processor, internal and external memories, a power source and one or more sensors. They are scattered in a special domain called a sensor field [26]. Each of the distributed sensor nodes typically has the capability to collect data, analyse them, and route them to a (designated) sink point [26-27]. The sink then may communicate with the user via Internet.

In addition, the user has an option to add sensor nodes with GSM-GPRS and 3G+GPRS. With these options, the sensor nodes would be able to making/receiving calls, making ‘x’ tone missed calls, sending/receiving SMS and etc. These options also create an opportunity for the development of warning-alert system as the sensor nodes would send a notification via SMS or missed call to the users in any events of environmental non-compliances.

One of the advantages of WSN is the sensor nodes would periodically sample and relay their sensor readings to a gateway connected to the Internet, allowing researchers around the world to access real-time environmental data [28-29]. Santini, Ostermaier et al. [30] for instance, has implemented the Ennowa (Environmental Noise Watcher) application for the collection and logging of indoor and outdoor noise pollution data based on the Tmote invent prototyping platform for wireless sensor networks.

On top of that, there are also proven commercialised sensors and systems available in the market. Brüel & Kjær UK Ltd. has developed an online noise monitoring system which allows the users remote control access to the instrument via mobile phone, PDA, iPhone or PC with Internet browser capability [31]. In advance to that, Smart Santander Project for example, has been developed by several companies and institutions including Telefonica I+D and University of Cantabria, aims at designing, deploying and validating in Santander and its environment is a platform composed of sensors, actuators, cameras and screens to offer useful information to citizens [32].

The EkoBus Project, which is funded by the European Union through its Future Internet Research and Experimentation (FIRE) program, also using the sensor nodes. The project envisions the deployment of 20,000 sensors in different European cities such as Belgrade and Pancevo (Serbia). 65 sensor nodes were deployed in two different locations; measuring 6 parameters of temperature, relative humidity, Carbon Monoxide (CO), Carbon Dioxide (CO2), Nitrogen Dioxide (NO2) and GPS location [33].

The above mentioned advantages would improve the environmental surveillance on construction site through enhanced information management and communication processes. Ghobakhlou, Zandi et al. [29] stated that the real time information from the fields provide accurate illustrations of current conditions while forecasting future conditions and risks, so that the users have a solid base to adjust strategies at any time. Instead of making decisions based in some hypothetical average condition, which may not exist anywhere in the reality, integrated approach of physical and technological based surveillance recognise differences and adjusts management actions accordingly.

However, the use of technological and physical surveillance for environmental management at the construction site in some situation complements each other. For instance, air quality monitoring station might detect the air pollution problem due to high quantity of Total Suspended Particulates (TSP) in air sample. However, it would only indicate the existence of the problem without informing the source of pollution. Thus, the inspector has to carry out physical inspection so that the source of pollution can be identified. The problem might be due to the vehicle movement, open burning activities, poor management of earth stockpiles and etc [34-35]. Subsequently, all relevant parties have to be notified on this matter so that rectification works can be done accordingly. Nevertheless, it is not to disregard the introduction of audio visual surveillance via live video streaming would give the same effect as physical surveillance in some extent. However, camera cannot complete the entire space in a single view [36] hence required deployment of many cameras with functional of pan angle, tilt angle and zoom to ensure full coverage of surveillance's site. As a result, it could not be economically deployed on site due to the cost and maintenance of the camera and the system.

## Conclusion

This paper has given an overview of the traditional and technology based surveillance on construction site. The review shows the weaknesses of the traditional surveillance and the advantages of the technology based surveillance. This paper also shows that, the use of technological and physical surveillance for environmental management at the construction site in some situation complements each other. While maintaining the physical surveillance or inspection as the backbone of the enforcement programs in the field of environmental management, the use of technology for surveillance would add value to the existing method. It creates possible implementation of emerging mobile information technologies through a combination of web or

Apps, mobile devices and sensory technologies for environmental surveillance at the construction sites, thus it will be taken forward in this research. As the success of the application depends on the right research philosophy, methodology and techniques, the focus of the other research papers would emphasis the understanding of the relationship and interaction between the user (human) and the application (computer) before developing any mobile application.

**Acknowledgements**

The authors would like to thank Universiti Teknologi Malaysia and the Ministry of Education, Malaysia for sponsoring this research.

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