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# Analysis of the constructive role of the Internet of Things in environmental protection and innovative improvements: Taking Shenzhen as an example

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***ABSTRACT :*** *With the rapid development of global urbanization, environmental problems are becoming increasingly serious. In order to minimize the cost of such development, there is a new need to improve the quality of environmental governance and the efficiency of environmental protection management. Based on this demand, the application of Internet of Things (IoT) technology in environmental protection is born. As an emerging technology and concept, IoT environmental protection provides new intelligent ideas and solutions for solving problems related to environmental protection such as environmental pollution, resource waste and energy consumption. Against this background, this paper will take Shenzhen City as an example, use literature research method, example analysis method and other methods to explore the concepts, principles and related applications of IoT environmental protection, and analyze its practice and constructive effects in Shenzhen City, so as to put forward more innovative as well as forward-looking development and improvement proposals, which will provide reference for other cities in coping with the test of sustainable development and ecological civilization construction.*

***KEYWORDS -*** *Internet of Things (IoT) technology; Environmental Governance; Intelligence; Shenzhen, China; Environmental protection*

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## I. INTRODUCTION

Internet of Things (IoT) technology, an online term selected as one of China's new vernacular keywords for 2020, refers to an immense network that combines a variety of different sensing devices with the Internet and aggregates them into a network that enables communication anytime, anywhere. The concept first appeared in Bill Gates' 1995 book "The Way of the Future".

In recent years, the Internet of Things (IoT) technology has become increasingly mature and has blossomed in various areas of our lives, such as transport, agriculture and electricity. In view of the concept of "sustainable development" and people's increasing awareness of environmental protection, the Internet of Things has also injected new vitality into environmental protection work, bringing a series of constructive effects.

Therefore, it is necessary to study and analyze the application of Internet of Things in environmental protection, which will provide more valuable experience for China and even the world in the practice of environmental protection, and bring them more forward-looking opinions on the construction of environmental protection in the new era of "sustainable development"[1] concept and "green water and green mountains are golden silver mountains" values.

According to the relevant information, the Internet of Things environmental protection refers to "the introduction of automation and information technology in the traditional environmental protection industry to achieve the scientific management of environmental protection system network", of which, "intelligent environmental protection" is a more important concept in the Internet of Things environmental protection. It refers to the advanced concept of building a highly perceptive environmental protection infrastructure environment with the help of a variety of technological solutions to achieve timely, interactive and integrated information perception, transmission and processing of environment-related indicators, in order to promote pollution abatement, environmental risk prevention, prevention of ecological civilization, ecological civilization and scientific development of environmental protection[2] .

Overall, IoT environmental protection is characterized by comprehensive sensing, high integration, and collaborative interaction.

## II. BACKGROUND ON SHENZHEN, CHINA

### 2.1Current Development Situation and Environmental Problems in Shenzhen City

Shenzhen, as China's pioneering reform and opening-up area, has been at the forefront of social, economic, scientific and technological development through a time span of close to 40 years. Shenzhen has developed a wide variety of high-tech in recent years, forming a series of industrial parks, and its GDP in the first quarter of 2023 even reached a staggering 777.219 billion yuan, a year-on-year increase of 6.5 per cent[3].

However, the rapid development of Shenzhen has also plunged the city into the plight of increasing population size and environmental pollution. For example, air quality and drinking water quality pass rate, for example, 08 to 13 years, the people of Shenzhen City, Shenzhen, air quality fluctuations are relatively large, such as drinking water quality pass rate is still lower than the same period in Beijing and Suzhou level of 100 per cent.

### 2.2 Shenzhen's Policy and Development Strategy for IoT Environmental Protection

As China's special economic zone and science and technology innovation center, Shenzhen has always been committed to promoting the development of IoT and environmental protection industry. 2015, Shenzhen proposed the project of "building smart environmental protection" and completed the project by the end of 18, during which, Shenzhen formulated a series of IoT environmental protection policies and development strategies.

First, Shenzhen encourages enterprises and research institutions to carry out innovative research and development in the field of IoT environmental protection. The Government provides financial support and tax incentives to encourage enterprises to increase R&D investment and promote the application of IoT technologies in environmental monitoring, resource management and energy efficiency.

Secondly, Shenzhen has vigorously promoted the construction of an Internet of Things (IoT) environmental monitoring system. Through the establishment of a network of intelligent sensors and a data acquisition system, various environmental indicators are monitored in real time to improve the accuracy and timeliness of environmental monitoring.

Such a series of investment in IoT environmental protection work has ushered in a constructive role for environmental governance in Shenzhen.

## III. IOT ENVIRONMENTAL PROTECTION IN SHENZHEN APPLICATION CASES

In view of Shenzhen City in the Internet of Things environmental protection in more applications, here in this paper focus on air quality monitoring and management, intelligent waste separation and treatment, intelligent water management in these three directions to explore.

### 3.1 Air quality monitoring and management

The application of the air quality monitoring sensor network is reflected in the fact that Shenzhen has established a large-scale air quality monitoring sensor network in various areas of the city. For example, in recent years in Bao'an District set up in the environmental protection equipment specializing in environmental management Osn. These sensors are connected to a cloud-based platform via IoT technology to monitor the concentration of pollutants in the air in real time, and the monitoring data can be made available to the public via mobile phone apps or websites, providing detailed air quality information. This data is important for the government and the public to formulate environmental protection measures and adjust daily activities[4].

Specifically, the mechanism and operating principles are:

Sensor Deployment: The air quality monitoring sensor network consists of multiple air quality sensors that are distributed in different locations to cover the air quality conditions in the monitored area. The sensors can be mounted on street light poles, buildings or other suitable locations.

Data collection and transmission: Each sensor will collect real-time air quality data from the surrounding environment, such as particulate matter concentration, sulfur dioxide concentration, nitrogen oxides concentration, and so on. These data will be transmitted to the central server or cloud via wireless communication methods such as Wi-Fi, LoRa WAN or mobile network.

Data analysis and processing: A system on a central server or in the cloud receives the data sent by the sensors and analyses and processes the data. This includes operations such as data storage, cleaning, calibration and integration. The system allows for real-time monitoring, trend analysis and visualization of spatial distribution of the data so that the user can understand the air quality situation.

"Acid rain" is now selected as an evaluation index for the effectiveness assessment of air quality monitoring and management. First of all, the acid rain in the atmospheric environment, through the 2021, 2022 more recent two years of Shenzhen ecological environment status bulletin data can be seen, give full play to the

Internet of Things environmental protection on the positive role of atmospheric monitoring and management may see more obvious results. The bulletin pointed out that "the annual average value of precipitation pH in 2021 was 6.13, a year-on-year increase of 0.68; the frequency of acid rain was 7.7%, a year-on-year decrease of 18.9 percentage points"[5] , and in 2022, "the annual average value of precipitation pH was 5.99, a year-on-year decrease of 0.14; the frequency of acid rain was 6.5%, a year-on-year decrease of 1.2 percentage points; acid rain pollution is significantly reduced"[6] .

### 3.2 Intelligent Waste Separation and Treatment

Interestingly, Shenzhen's Nanshan District has introduced smart bins that are equipped with sensors and communication devices to monitor the filling of the bins and the sorting of waste in real time.

In 2021, the Southern University of Science and Technology and FuTian District in Shenzhen also put into use two sets of intelligent underground rubbish bins[7]. The principle and mechanism of operation is similar to that of ordinary intelligent rubbish bins, which is:

Sensor technology: Smart bins are equipped with various sensors such as pressure sensors, infrared sensors and ultrasonic sensors. These sensors are able to sense information such as the capacity of the bin, how it is filled, and the type of waste in the bin.

Data collection and analysis: The data collected by the sensors is transmitted to a central server or the cloud via built-in IoT technology. This data includes information such as bin capacity, fill level, etc.

Intelligent management system: An intelligent management system on a central server or in the cloud analyses and processes the collected data. Depending on the capacity and filling level of the bins, the system can monitor and manage the operating status of the bins in real time.

Reminder and Alarm: When the capacity of the bin reaches a certain threshold or needs to be cleaned, the smart bin can be reminded and alarmed by sound, light or mobile apps so that relevant staff can take timely action.

Through the above operating principles and mechanisms, Shenzhen Smart Bin is able to achieve intelligent management and optimization of the waste disposal process, improve the efficiency of waste classification and resource utilization, and at the same time reduce manpower costs and environmental pollution.

For the waste treatment rate, the rate of harmless treatment of hazardous waste and urban domestic waste has reached 100% by the beginning of 2014[8] ; the IoT's intervention in waste treatment has been instrumental in this.

### 3.3 Intelligent Water Management

Similar to smart waste disposal and air monitoring, Shenzhen IoT Environmental Protection also uses advanced technologies and operational mechanisms in water management. The following are some possible operation mechanisms and principles:

Smart water meters and remote monitoring: IoT technology can be applied to smart water meters. Smart water meters are connected to the IoT through sensors and communication technologies to monitor and record water usage in real time. This data can be transmitted to the water management department through a remote monitoring system, which helps to accurately understand the consumption of water resources, peaks in water use and abnormal water use. By analyzing this data, appropriate management strategies and water saving measures can be formulated.

Water quality monitoring and early warning systems: Sensors and IoT-connected devices can monitor water quality parameters such as pH, dissolved oxygen, turbidity, etc. in real time. These data can be transmitted to the central control system of the water management department for real-time analysis and monitoring. Once abnormal water quality is detected, the system can issue an early warning and take appropriate measures to ensure water supply safety and environmental protection[9].

Water resources management and optimal allocation: By monitoring and analyzing data from water sources, reservoirs, water supply pipe networks, etc., water management authorities can understand the supply and demand situation of water resources in real time. Based on these data, they can formulate reasonable water resources scheduling plans to ensure efficient use and balanced distribution of water resources.

Finally, the management of river water quality, the aforementioned Shenzhen IoT intelligent water management has played a pivotal role in this indicator. Also referring to the 21-year State of the Environment Bulletin: "The water quality of the city's 310 rivers increased from 22.9 per cent to 50.0 per cent according to the ratio of river chiefs."[5] Among them, the Xixiang River and the Fengtang River showed the most prominent changes.

Overall, based on the background of the IoT environmental protection project implementation, the overall environmental governance and improvement effect in Shenzhen has been enhanced more significantly and assessed as favourable.

Now it is the turn of the Assessment of the effectiveness of resource use and savings. In recent years, the year-on-year rate of decline in carbon emissions in Shenzhen has been expanding year by year, exceeding the carbon emission targets of the "13th Five-Year Plan". With the support of IoT environmental protection, Shenzhen's ability to control energy has been gradually enhanced, of which 2020 is a mature period for Shenzhen to implement smart environmental protection.

According to the relevant bulletin data, "In 2020, the city's total energy consumption of 44.14 million tones of standard coal, the average annual growth rate of the "13th Five-Year Plan" of 2.5%, compared with the "Twelfth Five-Year Plan" reduced by 1.2 percentage points! "[10].

The following are the selected shares of energy consumption in Shenzhen in 2020: primary electricity and other energy account for 47.5%, coal for 11.4%, natural gas for 12.7%, and oil for 28.4%.

## IV. DISCUSSION AND FUTURE PERSPECTIVES

### 4.1 Challenges and Issues Facing IoT Environmental Protection

Throughout the development of the entire Internet of Things environmental protection, through the Shenzhen City of such an example of the city we can learn that in today's era, the Internet of Things environmental protection also exists in the following some of the more prominent problems:

First of all, the construction of the environmental protection department system is relatively dispersed, resulting in part of the "information island"[11] phenomenon, the comprehensive analysis of information resources is not in place; at the same time, the monitoring indicators are incomplete, the density of environmental sensing points is too low, and the stability of the monitoring technology is insufficient.

Secondly, like Shenzhen, the governments of other cities in the country strictly control the funding of information technology construction of various departments, and the information technology construction is not sufficiently coordinated, which to a certain extent has led to the serious loss of management and technical personnel of information technology construction of environmental protection departments.

### 4.2 Future Directions and Recommendations

In response to these similar issues above, and in conjunction with the specific case of Shenzhen, the construction of IoT environmental protection on a city-wide basis across the country can be improved as follows:

Define and continue to improve the environmental protection information construction management mechanism, and accordingly enhance the environmental protection information construction efforts to ensure and increase the "wisdom of environmental protection" of the capital investment, and continue to improve the construction of environmental protection sensing network, so as to further break the "information silos The predicament of "information silo" can be further eliminated. At the same time, municipal governments should also encourage the establishment of industry-university-research co-operation platforms, promote co-operation between academia and enterprises, and accelerate the transformation and application of scientific research results.

Based on the applications above and the analyses of the evaluations, here are some possible innovations for future development:

Innovation point one, the organic integration of IoT environmental protection with other fields: IoT for the environment is maturing, but its constructive role must be considered in relation to other areas of IoT if it is to be further expanded. The role of IoT technology in environmental protection should be presented as a cross interaction with other IoT technology fields - such as intelligent traffic management system, which realizes the organic combination of IoT traffic and environmental protection, and reduces tailpipe emissions by monitoring and adjusting the traffic flow; and the cross of IoT agriculture and environmental protection, monitoring the content of $CO^2$ in the air to achieve the control of carbon emissions at the same time, and so on.

Innovation point two, improving the conversion of information in IoT environmental protection: Environmental protection has always been a process of universal participation, in the construction of the Internet of Things (IoT), not only to emphasize the internal mechanism of the various layers of the IoT, but also to fully enable the extracted data or information to reach the masses of the people, such as in the part of the rubbish disposal, intelligent rubbish disposal of real-time status and basic classification knowledge needs to be known by the government departments, citizens, and other groups, so as to properly transformed into the appropriate

action. This is where the key to improving the conversion rate lies, because the effective information obtained by using IoT will eventually be translated into various practices of people in building an ecological civilization.

## V. CONCLUSION

Overall, the development prospects of the Internet of Things environmental protection is relatively bright. From a variety of data and information can be more intuitive to see today's era of Internet of Things technology applications in the field of environmental protection in the constructive role. However, no one thing can do 100% perfect, only by fully recognizing the shortcomings reflected in the development process can we better integrate into the process of fully integrating technological innovation and intelligent management in smart environmental protection, so as to truly create a complete and mature Internet of Things environmental protection system.

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