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Review of a Real-Time Infectious Waste Management System using QR Code

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***Abstract*—**In the management of industrial waste, conversion from the use of paper invoices to electronic forms is currently under way in developed countries. Difficulties in such computerization include the lack of synchronization between the actual goods and the corresponding data managed by the server. Consequently, a system which utilizes the incorporation of a QR code in connection with the waste material has been developed. The code is read at each stage, from discharge until disposal, and progress at each stage can be easily reported. This system can be linked with Japanese public digital authentication service of waste, taking advantage of its good points, and can be used to submit reports to the regulatory authorities. Its usefulness was confirmed by a verification test, and put into actual practice.

***Keywords*—**Infectious Waste, Electronic Manifest, Real Time Management, QR code.

I. Introduction

ALTHOUGH creative efforts in industrial activities toward zero-emissions have advanced, waste discharge in the modern society are an unavoidable issue. For disposal of such waste, compliance to laws and regulations are required, and the flow of waste management must be accurately managed. In order to manage the effective use of the resources and achieve proper waste disposal, the "Manifest System" (industrial waste management sheets) [1] has been applied as the social base in Japan and developed countries.

Currently, in order to effectively operate this manifest system, progress in the conversion of industrial waste management sheets in paper media to an electronic media manifest management which utilizes information communication networks, such as the Internet, has been made in developed countries. In the operation of the electronic manifest, benefits of computerization, such as uniform data management, are great, but on the other hand, verification of compliance with regard to the electronic data distributing in the information network and actual waste disposal is not synchronized, and multiple processes for disposal are needed, therefore the issue of rapid collation still remains. Moreover, implementation of a system which can handle infectious industrial waste, which is a special industrial waste subject to special control, from discharge to disposal is also required. Even if the electronic manifest is followed, sometimes a large disparity between waste disposal and data processing occurs.

In this article, in order to promote the use of an electronic manifest, a waste information management system by QR (Quick Response) code which resolves the above issues, and improves user convenience and support of information management, is proposed. While inputting manifest data to the information management system during waste discharge according to the laws and regulations, a unique QR code is issued to each discharge waste. The QR code is affixed directly to the actual waste, and always accompanies the waste. At each stage of progress in waste disposal, the specifics of the waste are read from the QR code, and data of the corresponding waste is updated by the information management system. Moreover, progress status of the waste disposal can be confirmed in real-time, by checking the QR code which can even be read cell phone, in the information management system. Furthermore, this waste information management system links JWNET of Japanese public digital authentication service which utilizes the electronic manifest with EDI (Electronic Data Interchange), and carries out networking.

II. Trends in Industrial Waste Management

Waste can be classified into industrial waste and general waste in Japan. Within waste occurring in business activities, there are 20 kinds which correspond to industrial waste and are regulated by the laws and regulations. The generator is required to properly dispose of such waste. In actuality, proper disposal, which is the subject of this article, is consigned to another party in most cases. The manifest system issues an industrial waste management sheet (Manifest) describing the name of the waste, name of the transporter, and the disposer, cautions during handling, etc., and allows distribution of the waste. By this manifest system, the responsibility of the generator and those consigned disposal of such waste can be clearly identified, leading to the prevention of illegal dumping. Furthermore, accurate information management regarding industrial waste is possible, and businesses can determine the treatment process and proper disposal of the consigned industrial waste.

Currently, all the industrial waste is covered by the manifest in Japan, and there is a method that uses a duplicate industrial waste management sheet, and another method that uses the same electronic data. The electronic manifest which uses electronic data has the advantage of computerization, such as management in an integrated fashion at an information process center. By computerization, data input and registration procedures in compliance with waste laws and regulations can be carried out, and errors and missing in description and missing information which occur in duplicate paper industrial waste management sheets can be avoided. Moreover, the

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generator, and the transporter, and the disposer do not need to specially send, collect, or collate the paper industrial waste management sheets, as relative data can be arbitrarily collected by inquiry to the information process center on the Internet. This means a large volume of data can be stored at the information process center, and the generator, the transporter, and the disposer which have stored the paper industrial waste management sheets up to now no longer need to do so, and do not need to worry about the worst possible scenario of lost sheets.

Regarding the expansion of an electronic manifest with such characteristics, the Japanese Ministry of Environment increased the target from 20% in 2008 to 50% in 2010, as a new reform strategy of the government IT strategy headquarters, but achievement is extremely difficult. Main reasons for this include insufficient implementation of maintenance of the information equipment and accumulation of information technology in small and micro companies related to industrial waste, and problems in double management of a method using the duplicate paper industrial waste management sheet and a method using an electronic manifest [2].

On the other hand, even in the companies which have already introduced the electronic manifest, duplication of data input has occurred in response to data input to the management information system which has originally used in the company's own, such as receiving orders, progress management and billing system, to the management information system by private itself and the data input to the information process center in response of the electronic manifest. The condition of multiple entries has also occasionally been observed. Although diversification of data input application is considered in the current electronic manifest operation, including the preparation of an EDI connection channel and the availability of connection by ASP (Application Service Provider), the current application condition is difficult for mid-small and micro companies, for example, adjustment to the technical standards, the ASP usage fee and the amount used for the receiving fee. In consideration of these, a little more time is assumed to be needed for the introduction and use of the manifest system.

Moreover, the generator must register the necessary information to the information process center within 3 days after the industrial waste is passed on to the transporter or the disposer. However, when compared with the method where the distribution of waste is matched with the paper industrial waste management sheet, there is no synchronization between the waste and the waste data which should be managed by the specific information process center. Furthermore, when inquiring about actual waste data, multiple processes are required, and it takes many hours for a reply. Especially for infectious industrial waste, an industrial waste subject to special control, speed in prompt disposal from the time of transfer by the generator, and the issue of non-synchronization, may hinder the very purpose of the waste management itself.

In this way, although electronic manifest has advantages such as promotion of information sharing and transmission, which are merits of computerization, some issues still remain. This article proposes and constructs a system which resolves these issues, and promotes the expansion of the electronic manifest.

III. System Construction

A. System Requirements

The system proposed in this article has the following characteristics.

a) Improvement in the synchronization of waste and its data.
b) Real-time disposal progress management
c) Simplification of waste inspection and progress reports
d) Coordination with the current management information systems
e) EDI linked to JWNET

B. System Configuration

The waste management system constructed in this article is a client server system as shown in Fig. 1, with the generator, transporter, or disposer as the client, and configured by the server as the system central core. However, in consideration of user operability and the introduction of a comparatively easy information device, a function which reads a QR code, using it as the system terminal, has been added.

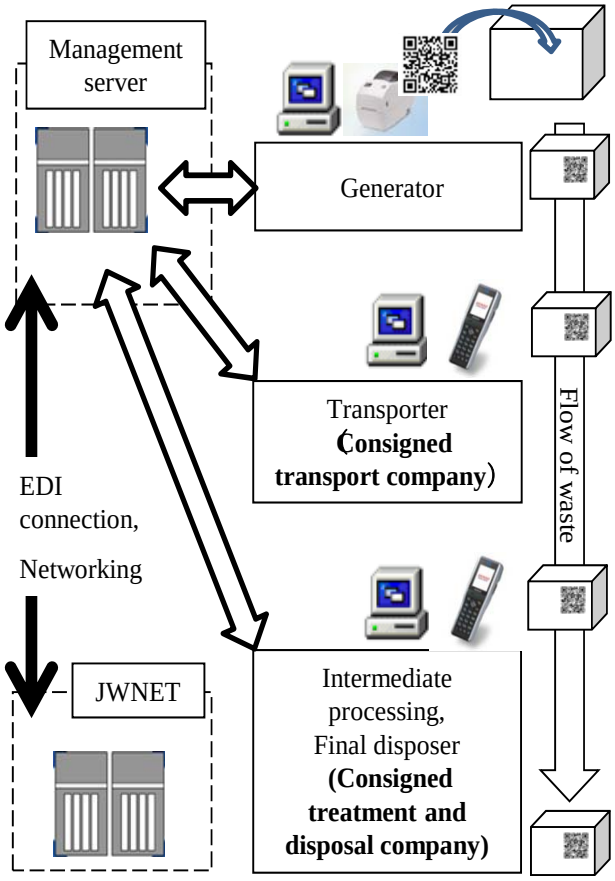

Fig. 1 Client server system developed by this research

For example, as shown in Fig. 2, the generator issues a QR code for the waste, but this can be done on a normal PC and printer at the office. Moreover, the transporter can inspect the

waste, with a cellphone terminal to read the QR code. Since the transporter can do this simply with a cell phone, no special information terminal needs to be prepared. The disposer can update the progress of the inspection and disposal, with the QR code of the waste delivered by the transporter. The terminal, such as code reader which is comparatively cheaper price and easier to handle, is connected to the cell phone or PC at the company.

C. System Operation

Operation procedures are described based on the general cases shown in Fig. 2. Fig. 2 shows how this system transmits and receives according to the management sheet and receiving sheet used with the duplicate industrial waste management sheet as a case of Japan.

a) Data input and QR code issuance by the generator
b) Discharge reservation and attaching the QR code
c) Receiving and inspection of the waste by the transporter
d) Report of receiving and inspection of the waste by the transporter
e) Transport of waste by the transporter
f) Receiving and inspection of waste by the disposer
g) Report of receiving and inspection of waste by the disposer
h) Disposal of the waste
i) Report of the completion of the receiving and inspection of the waste by the disposer

This is done in the same manner as the report of receiving and inspection.

Linking to JWNET, which operates the electronic manifest, is achieved by networking with the management server of this system and the management server of JWNET, using a specified EDI connection, each time an event is carried out.

Moreover, users of this system can search for waste data in this system using the serial number or QR code, etc. If the data pertains to waste of the company, the statistically calculated results can be output.

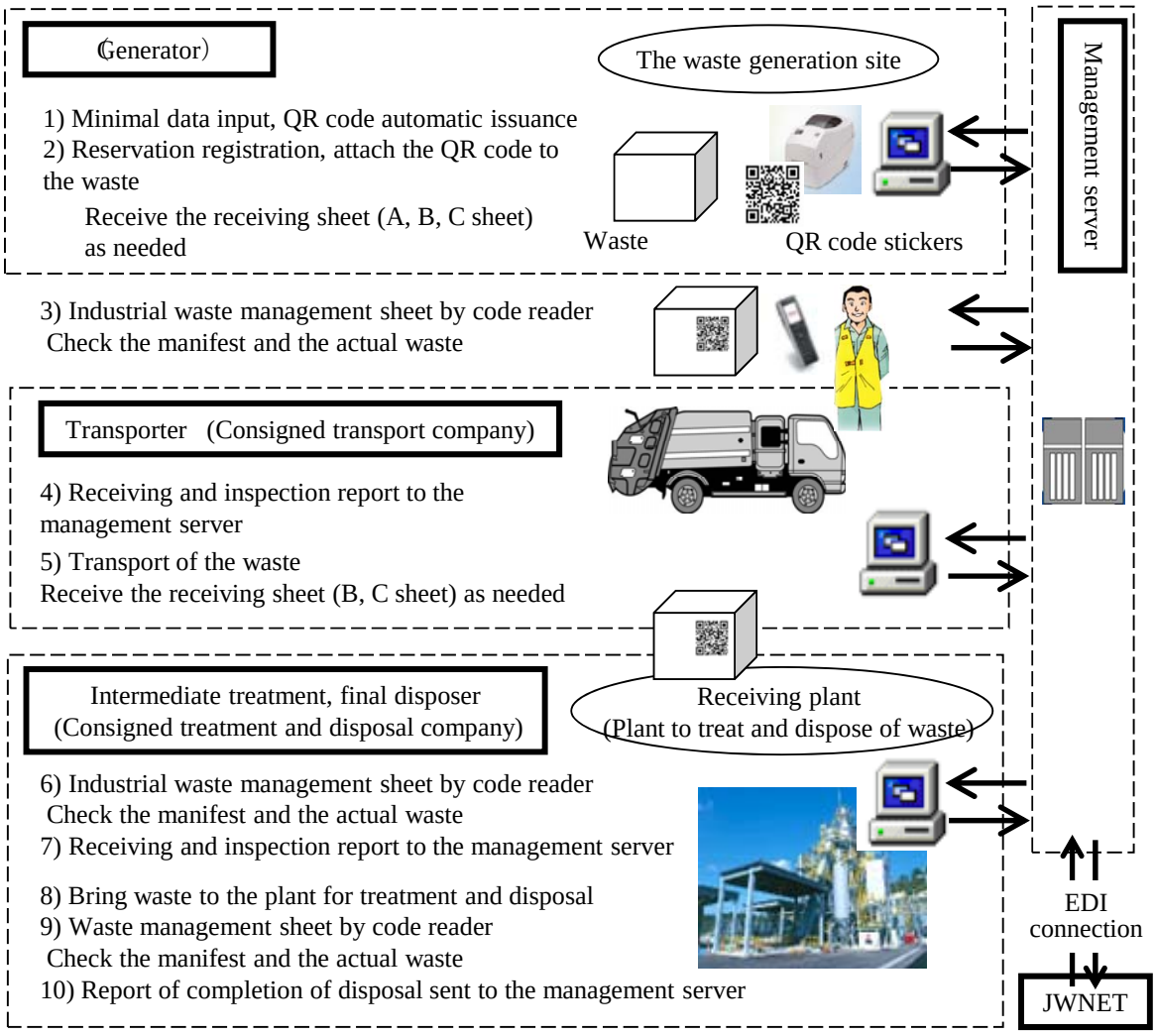

Fig. 2 Real time industrial waste management system using QR code

IV. Data which should be Described by QR Code

Procedures a) - i) described in the previous chapter were temporarily implemented. For actual operation, to what extent information should be included in the QR code must be fully

considered. In particular, there is a similar system which uses RFID (Radio Frequency Identification) [3]. Generally, one characteristic of the QR code is that it can be inexpensively established. However, unlike RFID, data renewal is not possible with a QR code sticker, so care and consideration as to the contents described on QR code are needed. Changes in the progress of the waste disposal cannot be written in the QR code sticker. Therefore, progress of the waste disposal must be confirmed by the corresponding attached serial number which is minimally described in the QR code, and by inquiring to the central core of the system, the management server.

In fact, at a hearing survey of some businesses and supervisory authorities, many were aware that the serial number, name of the generator, name and kind of the waste, amount, style of the packing, name of the transporter (consigned transport company), and name of the disposer, and remarks are needed[4]. This is because, if there is a failure in the Internet connection environment while verifying the data that specifies the waste during one of the disposal processes, the name of the generator, the name and kind of the waste, amount, style of the packing, name of the transporter, and the name of the disposer can be read from QR code, and would prove to be effective in actual operation, even though synchronization of the waste and the data may be lost.

V. Verification Test

A. Outline of the Verification Test

A verification test was carried out in order to validate the effect of the developed real-time waste management system [5]. This was a hospital which handles infective waste defined by law as medical industrial waste subject to special control. Infective waste requires a shorter treatment and disposal time after transport from the site of the generator, and prompt electronic manifest data processing ensures the synchronization of actual waste and data.

The discharge frequency of waste was approximately once or twice a week, and approximately 2t of three kinds of waste, including infective waste, were discharged each time.

The transporter was an authorized collection and transport business of industrial waste, subject to special control within the discharge region, and the disposer was an authorized disposal business of industrial waste subject to special control within the discharge region. The period of the verification test was for two months, from February to March 2009.

Moreover, it should be noted that data transmission was carried out by VPN connection which was not connected to the hospital LAN network, so that the system developed for use with the verification test would not interfere with the core operating system of the hospital. Since this was still in the verification phase, this was carried out in order to prevent any personal or hospital data, such as patient data within the hospital, from possible leak or falsification.

System operations, except for a part, were carried out as described in the previous chapters. In this verification test, the transporter used same driver to collect and transport from the generator, and no specific direction regarding transport was provided. The driver read the QR code by his usual cell phone, receiving and inspecting the contents of the waste, and sent a report of receiving and inspection completion to the management server. After the management server updated the electronic manifest data status of the corresponding waste, a receiving and inspection report was sent to the cell phone of the driver. The driver received the receiving notification and began transport of the waste to the disposer.

Furthermore, the networking of the management server with JWNET Japanese public digital authentication service, managed by Japan Industrial Waste Technology Center, was carried out every 30 minutes.

B. Implementation Conditions of the Generator

The generator switched from handwritten input to PC input, and the waste disposal conditions could be confirmed in real-time. As shown in Fig.3, the generator who used to prepare a handwritten industrial waste management sheet, prepared an electronic manifest by PC input. This contributed to expansion of the electronic manifest as promoted by the Japanese government. Moreover, up to now, the generator used a set description of the contents, such as the waste generation site, the consigned transporter, the name of the disposer, address, telephone number, etc. However in the verification test, by using the system developed in this study, the business only needed to input its ID and password, and did not need to input the set description of the contents. The generator could carry out the proper discharge procedures in compliance with law, just by selecting the kind and name of the waste, and inputting the amount and units.

Through this verification test, the generator determined usability of the system developed by this study by the following items.

a) No need to purchase the paper industrial waste management sheet

The paper industrial waste management sheet which was used by the generator when discharging industrial waste, no longer needs to be regularly purchased. However, using the electronic manifest is not free, and there are various payment systems. So, a fee has to be paid by the discharging party to manage the industrial waste either as the paper management sheet or the electronic manifest. Hence, the difference here is that no action for purchase procedures is required for the electronic manifest.

b) No need to write the set description of contents

Actions to write the set description of contents such as the name of the transporter and the disposer, address, telephone number, etc., are no longer needed.

c) Easy to make corrections before registration

Up to now, the generator had to make a reservation and preparation for its discharge. When discharging waste, if the contents were different from that listed at the time of reservation, it was confusing for the generator as to what procedures were needed for the transporter and the disposer, or how to make revisions. However, in the system developed in this study, the electronic manifest can be corrected and deleted any time before the waste is delivered to the transporter.

d) No need to store the paper industrial waste management sheets anymore

Previously, the generator needed to manage and store copies of multiple paper industrial waste management sheets for one waste discharge, such as a copy of the paper industrial waste management sheet prepared at discharge, a copy of the delivery report to the transporter, and a copy of the report of completion of treatment and disposal. In the system developed in this study, the electronic manifest of the waste is integrated and recorded in the database, so the generator can carry out operations such as confirmation, and always be well managed. Moreover, the public electronic manifest is stored in JWNET linked to this system, so the generator does not need to store data regarding the waste on its own.

e) Automatic preparation of the status report for issued industrial waste management sheets

Introduction of the system developed by this study

Fig. 3 Change of scene in waste generator

Up to now, submission of a status report for paper issued industrial waste management sheets was required by the government to the generator, and was prepared by transcribing the industrial waste management sheet. However, this report can be automatically prepared by the system developed in this study. Moreover, trends in waste discharge can be identified by exporting the electronic manifest in CSV format, and the information material can be provided for waste countermeasures and environment protection measures.

C. Implementation Conditions of the Transporter

The driver arranged by the transporter, receives the QR code sticker from the generator, and reads the QR code by a cell phone, and confirms the kind, name, and amount of the waste, as shown in Fig.4. Next, the driver receives and inspects the waste when loading, at the waste storage location of the generator. The driver reads the QR code by a cell phone again, and sends a receiving and inspection report from a cell phone application to the management server with one click. The management server receives the receiving and inspection report, and the electronic manifest data is processed. Report of completion of the receiving and inspection and direction of transport is sent to the driver in charge.

When compared with handling the paper industrial waste management sheet, actions such as reading the QR code and sending data, such as the receiving and inspection report were added for the transporter. These operations are needed for real-time management of the waste, and only take a few seconds to perform.

Through this verification test, the transporter determined usability of the system developed by this study by the following items.

a) The driver reads the QR code by cell phone, and confirms the discharged waste description

b) After confirmation of discharge description, the driver removes the waste from storage

Fig. 4 Changes in delivery

a) Easy to report of receiving and inspection

Previously, regarding receiving and inspection at the generator, the transporter could determine its response regarding an order made by the generator by submitting a copy of the paper industrial waste management sheet to the factory after 17:00pm, after the collection and transport operations of the day were completed, and registering it in the core operation system and JWNET. However, in the system developed by this study, receiving and inspection can easily be reported in

real-time by a cell phone and an application.

For the following two items, there was the same effect as experienced by generator.

b) No need to store the paper industrial waste management sheet anymore

c) Automatic preparation of the status report for issued industrial waste management sheets

D. Implementation Conditions of the Disposer

The transporter carried the waste to the disposer and the disposer carried out receiving and inspection. Previously, the description in the duplicate paper industrial waste management sheet was hand written, imprinted with a seal, and entered into the central core operating system by the disposer. By the system developed in this study, the disposer can register the data by just reading the QR code, and confirm the contents.

When compared with handling the paper industrial waste management sheet, actions such as reading the QR code increased for the disposer with the introduction of the system developed by this study. Although these operations are required in the real-time management of the waste, they only take a few seconds.

Through this verification test, the transporter determined usability of the system developed by this study by the following items

a) No need to write the set description contents

b) Easy to report of receiving and inspection, and progress

c) No need to store the paper industrial waste management sheet anymore

d) Automatic preparation of a status report of issued industrial waste management sheets

E. Full-Scale Operation after the Verification Test

The verification test could confirm that the developed system worked, and was user convenient. Accepting these results, this system was incorporated at the site where the verification test was performed, and full-scale operations have been carried out. In over three years of the full-scale operations, no failures have been observed.

During this period, specifications of JWNET's EDI (Electronic Data Interchange) were revised, and in response, the communication program was modified. Moreover, specifications of the developed system were publicized through presentations at academic meetings, etc., and distributed to interested parties. As a result, the product takes advantage of the achievements of this study and others have started to appear on the market.

VI. Conclusion

The purpose of the paper was to promote an electronic manifest, and to propose a waste disposal system which resolves problems such as non-synchronized verification of compliance between the electronic data and the actual waste, and which can handle waste which requires prompt disposal, such as infective industrial waste.

Moreover, system requirements of this proposed system were determined, and the design and development of a system utilizing a QR code, which can be easily used even by mid-small and micro companies. Convenience for all legally related users, including the generator, the transporter, and the disposer could be improved, and information management could strengthen.

Furthermore, a verification test to validate usability of the system which was developed by this study was carried out, by actually introducing the system to a central hospital in the region. As a result, validity of the developed system could be validated, and following usability could be confirmed.

a) No need to purchase the paper industrial waste management sheet

b) No need to write set descriptions of the contents

c) Easy to make corrections before registration

d) Easy to report receiving and inspection, as well as progress

e) No need to store the paper industrial waste management sheet anymore

f) Automatic preparation of the status report of issued an industrial waste management sheet

By taking advantage of these usability features, a system which achieves real time waste management could be established. This study is considered to be a great contribution, not only from the standpoint of improvement of the operations, but also from the standpoint of an environment business in accordance with law, compliance measures, and the security management of the company.

As for developments in the future, the authors plan to gather actual operation cases and achievements, by expanding this industrial waste real-time management, in coordination with hospitals and other generators.

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