Early-Warning Lights Classification Management System for Industrial Parks in Taiwan

Yu-Min Chang, Kuo-Sheng Tsai, Hung-Te Tsai, Chia-Hsin Li

Abstract—This paper presents the early-warning lights classification management system for industrial parks promoted by the Taiwan Environmental Protection Administration (EPA) since 2011, including the definition of each early-warning light, objectives, action program and accomplishments. All of the 151 industrial parks in Taiwan were classified into four early-warning lights, including red, orange, yellow and green, for carrying out respective pollution management according to the monitoring data of soil and groundwater quality, regulatory compliance, and regulatory listing of control site or remediation site. The Taiwan EPA set up a priority list for high potential polluted industrial parks and investigated their soil and groundwater qualities based on the results of the light classification and pollution potential assessment. In 2011-2013, there were 44 industrial parks selected and carried out different investigation, such as the early warning groundwater well networks establishment and pollution investigation/verification for the red and orange-light industrial parks and the environmental background survey for the yellow-light industrial parks. Among them, 22 industrial parks were newly or continuously confirmed that the concentrations of pollutants exceeded those in soil or groundwater pollution control standards. Thus, the further investigation, groundwater use restriction, listing of pollution control site or remediation site, and pollutant isolation measures were implemented by the local environmental protection and industry competent authorities; the early warning lights of those industrial parks were proposed to adjust up to orange or red-light. Up to the present, the preliminary positive effect of the soil and groundwater quality management system for industrial parks has been noticed in several aspects, such as environmental background information collection, early warning of pollution risk, pollution investigation and control, information integration and application, and inter-agency collaboration. Finally, the work and goal of self-initiated quality management of industrial parks will be carried out on the basis of the inter-agency collaboration by the classified lights system of early warning and management as well as the regular announcement of the status of each industrial park.

Keywords—Industrial park, soil and groundwater quality management, early-warning lights classification, SOP for reporting and treatment of monitored abnormal events.

I. INTRODUCTION

BECAUSE the underground environment is often obscure, clarifying the scope of soil and groundwater pollution is possible only if successful identification of contamination sources has been performed. In addition, the transport and chemical transformation process are also difficult to evaluate without systematic assessment and investigation [1], [2]. Since the "Soil and Groundwater Pollution Remediation Act [3]" was promulgated in 2010, the Taiwan EPA has carried out a series of pollution investigation and verification on the high pollution potential factories of the specified industrial categories. The results indicated that the inappropriate industrial behaviors often lead to soil and groundwater pollution, including production, use and storage of toxic chemicals and heavy metals [4]-[6].

The industrial land in Taiwan is estimated to be over 83,000 acres and 44% of the total area is used for industrial parks [7]. Because the intensity of industrial production per unit of land area is high, the industrial parks are supposed to be the districts with high potential of soil and groundwater pollution. Under the high population density, the ground highly develops. A large number of industrial parks are surrounded by the commercial districts, residential districts and even cultivated lands [8]. Once the safety accidents or environmental pollution incidents occur, the residents' health and food safety will soon be affected, which easily brings about social panic and becomes the focus of public concerns.

To prevent soil and groundwater pollution in the industrial parks, the Taiwan EPA amended the "Soil and Groundwater Pollution Remediation Act" in 2010, and ordered that the industry competent authorities should regularly test soil and groundwater quality and submit the resulting data to the local environmental protection competent authority [9].

Whereas an industrial park is the vast area with a large number of factories of different industrial categories and the management responsibility is involved with the environmental protection and industry competent authorities at all levels, the Taiwan EPA has also promoted the action programs of soil and groundwater quality management for the industrial parks since 2011. The main tasks are: (i) to broaden the environmental monitoring duty so as to gather the environmental background information; (ii) to reinforce the verification of the pollutant source and administrative controls to mitigate the pollution; (iii) to set up the early warning groundwater well networks in order to protect the surrounding residents; (iv) to enhance the collaboration to deal with the environmental problems. The early-warning lights classification management system presented in the action program is not only made to be the basis of the decision making and the communication with the public, but used for the cooperation among the competent authorities and supporting measures. Finally, the pollution prevention and early warning monitoring management of the industrial parks can be efficiently carried out and the sustainable use of

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industrial land will be realized. The present paper illustrates the principles and framework of the lights classification management system, and the accomplishments as well.

II. Lights Classification Management System

Soil and groundwater pollution events, referred to the monitoring data of soil or groundwater quality exceeding the regulatory pollution control standards, in the industrial parks have been on the rise in the recent years, and it often takes a huge amount of resources and money to execute monitoring, investigation and remediation. Therefore, it is strongly suggested to perform active management by distributing the administrative resources effectively. Firstly, a regular monitoring and reporting procedure is proposed to carry out in every industrial park; then the environmental protection agencies implement pollution investigation and verification on the high polluted potential industrial parks via early-warning lights classification management system.

The Taiwan EPA integrated and analyzed the monitoring results of the industrial parks and the relevant laws and regulations, and thus formulated a 4-light classification management system. Each industrial park was classified into red, orange, yellow or green light according to its monitoring data of soil and groundwater quality, regulatory compliance, and regulatory listing of control site or remediation site. The definition, objectives and action of each light are listed in Table I.

If a pollution event exists in an industrial park and the pollution has also been detected in the outer surroundings, such an industrial park shall be labeled "red light." Regarding that the pollution investigation and remediation can't be conducted in a short time, the risk assessment and management should be implemented as soon as possible to protect human health. The main tasks of red-light industrial parks also include investigating pollution sources, delineating the polluted area, pollution reduction and establishing the early-warning groundwater monitoring well networks between the polluted area and the downstream area. In addition, the pollution cutoff or hydraulic control measures on the boundary of the industrial park are supposed to be taken if necessary.

If an industrial park has a pollution event yet still remaining inside the park, it shall be labeled as an "orange-light" industrial park. It is urgent to adopt measures of risk management; then to delineate the polluted area and to establish the early-warning groundwater monitoring well networks on the boundary of the industrial park are also required. The industry competent authorities are supposed to provide the environmental protection agencies with the manufacturing and operating information of the factories around the polluted sites so as to assist the verification of the pollution sources. If the site has a clear source of soil or groundwater pollution, and the concentrations of pollutants exceed those in soil or groundwater pollution control standards, the environmental protection competent authority shall publicly declare it a soil and groundwater pollution control site and order the polluter, potential polluter, or interested party of the polluted land to perform the pollution improvement.

There are two types of "yellow-light" industrial parks requiring sustained attention. One is the industrial parks that ever had abnormal monitoring data, and the pollution sites are all still regulatory listed. The other is the industrial parks with normal monitoring data but without completing the regulatory monitoring and reporting procedure yet. The objectives for the former one are to enhance the pollution improvement and the early warning monitoring so as to cancel the regulatory listing of the pollution sites as soon as possible; those for the latter one are to speed up establishing the monitoring well networks in the industrial parks, to regularly test the soil and groundwater quality and submit the resulting data to the local environmental protection competent authorities for future reference.

If an industrial park completing the regulatory monitoring and reporting procedure has normal monitoring data consecutively, it will be labeled as "green light." Enhanced management of the potential pollution source and monitoring frequency reduction for conserving the administrative resources are suggested. In addition, if there are abnormal monitoring data due to the geological background concentration, the groundwater use and management should be concerned. An industrial park with industrial property of low pollution potential confirmed by the local environmental protection agency is also evaluated as "green light."

If an industrial park is still being designated, not under construction yet, it will not be evaluated by the lights classification management, but the environmental protection agencies at all levels should keep tracing the progress of development. As for the industrial park constructed by stages or by zones, the industry competent authority should obey the laws and the requirements of the environmental assessment to conduct soil and groundwater monitoring gradually according to the proportion of the developed land area.

III. Accomplishments

In Taiwan, there are 151 industrial parks occupying 44% of total industrial land area. According to different developers and the relevant management laws and regulations, these industrial parks can be classified in 7 categories, including public parks, private parks, local government-developed parks, science-based industrial parks, export processing zones, environmental technology parks, and agricultural technology parks.

Since 2011, the early warning lights classification management system for nationwide industrial parks has been promoted by the Taiwan EPA. A series of systematic investigation of soil and groundwater pollution were carried out and the resources among competent authorities were allocated. It was the first time to use 4-level lights, including red, orange, yellow and green lights, to symbolize the current status of the monitoring management and administrative control of pollution. Combined with the pollution potential assessment, the system proposed a priority list of implementing investigation and management for all the industrial parks in Taiwan, such as monitoring of background quality, establishing early-warning groundwater well networks and investigation/verification of pollution. Once a pollution event

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happened, the environmental protection and industry competent authorities gathered to deal with it and made an announcement to the public.

TABLE I
THE DEFINITION, OBJECTIVE AND ACTION OF EARLY-WARNING LIGHTS CLASSIFICATION MANAGEMENT SYSTEM

Light Color	Definition	Objective	Action	Priority
Red	The pollution expanding out of the park	1. To assess and manage the risk	1. To perform the risk assessment and management measures of the polluted region inside and outside the park	More urgent
		2. To cutoff the pollution source	2. To search out the source of pollution and adopt necessary response measures	
		3. To set up early-warning monitoring well networks	3. To complete the early-warning monitoring networks on and outside the boundary	
		4. To prevent the expansion of pollution	4. To set up pollution isolation measures on the boundary	
Orange	The pollution remaining inside the park	1. To strengthen the defending line on the boundary	1. To complete the early-warning monitoring networks on the boundary or to restrain the scope of pollution	Urgent
		2. To assess and manage the risk	2. To perform the risk assessment and management measures for the pollution which can't be improved in a short time	
		3. To search out the source of pollution and mitigate the effect of pollution	3. To clarify the scope of pollution and adopt improvement measures	
Yellow	1. The sites with abnormal monitoring data still being regulatory listed	1. To speed up the procedure of improvement	1. To enhance assisting the improvement and early-warning monitoring	Sustained attention
	2. Normal monitoring data without completing the regulatory monitoring and reporting procedure	2. To complete the regulatory monitoring and reporting procedure for future reference	2. To complete and enhance the function and effectiveness of the monitoring network	
Green	Normal monitoring data with completing the regulatory monitoring and reporting procedure; industry of low pollution potential	1. To manage the potential source of pollution	1. To enhance auditing environmental regulations on the potential source of pollution	Regular attention
		2. To manage the geological background concentration	2. To manage the groundwater use	
—	Underdeveloped	1. To keep tracking the developing progress	1. To track the development schedule and the current status of the factories within the park	—
		2. To execute the environmental background monitoring in advance	2. To carry out the monitoring plan via the Environmental Impact Assessment Act	

In 2011-2013, there were 44 industrial parks selected and carried out different investigation, such as the early warning groundwater well networks establishment and pollution investigation/verification for the red and orange-light industrial parks and the environmental background survey for the yellow-light industrial parks. Among them, 22 industrial parks were newly or continuously confirmed that the concentrations of pollutants exceeded those in soil or groundwater pollution control standards. To deal with the pollution events, the further investigation, groundwater use restriction, listing of pollution control site or remediation site, and pollutant isolation measures were implemented under the collaboration between the local environmental protection and industry competent authorities.

As for the red-light industrial parks with higher risks and dangers, the risk assessment and management measures were conducted in the first priority, such as inquiring the food factories in the industrial parks and the surrounding residents about the groundwater use, sample testing the groundwater quality, and informing them to stop using the polluted groundwater. The exposure pathways of the pollution were supposed to be eliminated as few as possible.

After incorporating the pollution investigation with administrative control measures, the pollution improvement and the adjustment of lights were realized gradually. By the end of 2013, the quantity of the red and orange-light industrial parks decreased from 37 to 32; that of the yellow-light decreased from 114 to 67; that of the green-light increased from the zero to 52.

As for the abnormal monitoring data detected in the industrial parks, the administrative resources of the industry and environmental protection competent authorities was coordinated and integrated, and the "Standard Operation Procedures (SOP) for Reporting and Treatment of the Monitored Abnormal Event in an Industrial Park" was proposed to deal with the pollution events as shown in Fig. 1.

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STEP 1

Industry competent authorities submit monitoring data for future reference and implement preliminary response measures

1. To submit monitoring data for future reference
2. To implement preliminary response measures assisting investigation on the source of the pollutants

STEP 2

Industry competent authorities evaluate to carry out the improvement

1. If there is only soil pollution, the improvement can be carried out by the industry competent authorities under the permission of the environmental protection agencies.
2. The environmental protection agencies establish early warning groundwater monitoring well networks on the boundary of the industrial park if necessary.

STEP 3

Environmental protection agencies implement investigation/verification

1. To declare publicly the site with a clear pollution source a soil or groundwater pollution site and conducting routine supervision
2. To initiate and promote the response sharing mechanism

STEP 4

The monitored abnormal area is to be declared as a soil or groundwater pollution control site

The industry competent authorities and environmental protection agencies collaborate to take response and remediation measures.
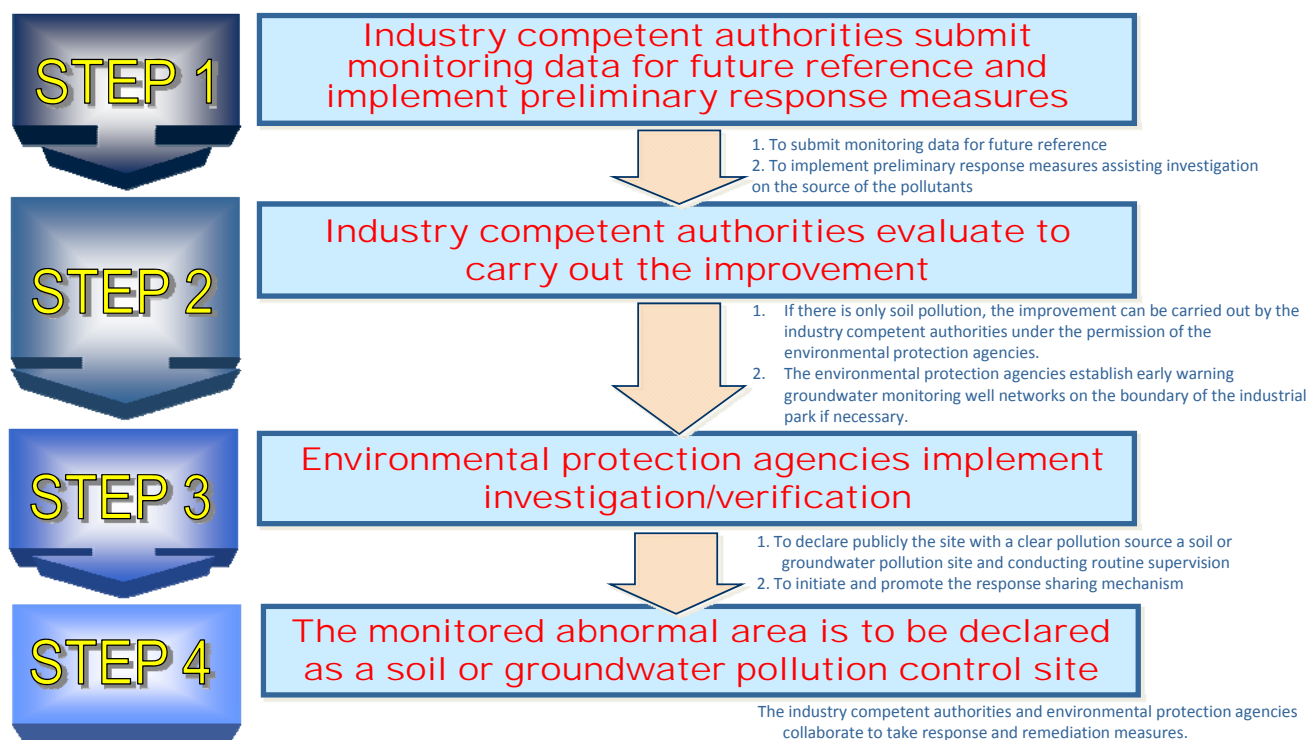
Fig. 1 The SOP for reporting and treatment of the monitored abnormal event in an industrial park

The strategies were composed of four steps, including: (i) the industry competent authority's performing the preliminary response measures to assist the investigation on the sources of the soil or groundwater pollutants; (ii) the local environmental protection authority's estimating the scope and extent of pollution and carrying out the management of human health risk, and establishing early-warning groundwater monitoring well networks on the outer boundary of the industrial park if necessary; only if there was no groundwater but soil pollution, the industry competent authority's performing the improvement of pollution voluntarily; (iii) pollution investigation implemented by the local environmental protection authority or verifying the improvement to check out if the pollutant concentrations less than the control standards; (iv) public declaration of the regulatory site so as to charge the polluters and the relevant agencies with pollution emergency response and improvement.

IV. Future Work

The early-warning lights classification management system has been promoted by the Taiwan EPA since 2011, and it has the initial positive effect of the implementation of environmental background information collection, early warning of pollution risks, pollution investigation and control, information integration and application, and inter-agency collaboration of pollution response.

The development regulations and operations management differ from the types of industrial parks. In the beginning, the industry competent authorities of different types of industrial parks were not very aware of their responsibility and authority. In addition, the shortage of budget allocation and the supporting regulations were still the difficulties yet to be overcome. It was found that the present control measures could not apply to every case. To improve the environmental management system of the industrial parks, the relevant regulations and supporting measures will be drafted and proposed to enhance the inter-agency communication and collaboration. Moreover, the performance management index will be evaluated to track the progress and results of environmental monitoring and management of each industrial park.

Finally, on the basis of the inter-agency collaboration, the self-initiated quality management of industrial parks will be realized progressively by means of the classified lights system of early warning and management as well as the announcement of the reports implemented by the environmental protection agencies and the newest lights distribution of nationwide industrial parks on a regular time schedule.

References

[1] G. Gzyl, A. Zanini, R. Frączek, K. Kura, "Contaminant source and release history identification in groundwater: A multi-step approach," *Journal of Contaminant Hydrology*, vol. 157, pp. 59–72, 2014.
[2] D. J. Lapworth, N. Baran, M. E. Stuart, R. S. Ward, "Emerging organic contaminants in groundwater: A review of sources, fate and occurrence," *Environmental Pollution*, 163, pp. 287–303, 2012.
[3] Soil and Groundwater Pollution Remediation Act, Taiwan, R.O.C., 2000.
[4] Environmental Protection Administration, "Investigation of Potential Soil and Groundwater Contamination of Abandoned Industrial Sites (No. EPA-101-GA102-02-A222)," Taiwan, R.O.C.

[5]   Environmental Protection Administration, "Management, Audit, and Consulting Services of the Soil Pollution Inspection Information on Land of Designated by the Central Competent Authority by Public Announcement (No. EPA-102-GA11-03-A027)," Taiwan, R.O.C.
[6]   Environmental Protection Administration, "Investigation and Verification of Soil and Groundwater Chlorinated Solvents Pollution Potential in Operating Factories (No. EPA-101-GA12-03-A235)," Taiwan, R.O.C.
[7]   The Statistical Yearbook of Construction and Planning Agency Ministry of the Interior, Taiwan, R.O.C., 2013.
[8]   Taiwan Factory Information Service, http://120.126.138.196/idb2011/, Industrial Development Bureau, Ministry of Economic Affairs, Taiwan, R.O.C.
[9]   Regulations for the local industry competent authorities regularly testing soil and groundwater quality and submitting the data for future reference, Environmental Protection Administration, Taiwan, R.O.C, 2011.