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# Study on Hazards of Chemical Fibre Wastewater and Evaluation of Uncertainty in Environmental Monitoring

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## ABSTRACT

China has a typical labour-intensive chemical fibre industry characterized by high energy consumption, severe pollution tendencies, and low resource utilization rate. The chemical fibre industry seriously harms the environment due to its small production scale, single product variety, low resource utilization efficiency, and weak technology strength. Investigating wastewater generated by chemical fibre production and improving the measurement uncertainty of monitoring factors are significant to chemical fibre wastewater treatment and environmental protection. A review of related literature on wastewater pollution in the chemical industry is conducted to summarize the types of wastewater hazards in the chemical fibre production process. An environmental monitoring uncertainty model is used to measure the wastewater monitoring uncertainty of a chemical fibre enterprise in Jilin City, Jilin Province in China. Findings show that the hazardous types of chemical fibre wastewater include polluting the surrounding environment, endangering human health, and destroying existing biodiversity. The monitoring quality reliability of the extended uncertainty model for the pH value, chemical oxygen demand, ammonia-nitrogen, and total phosphorous used in this case is superior to the direct chemical numerical detection quality. The monitoring uncertainty of chemical fibre wastewater can be further improved by perfecting the chemical fibre production process and the wastewater treatment process. Its environmental hazards can also be relieved by improving the environmental monitoring industry of wastewater and strengthening the R&D of related virtual instruments. This study can serve as a reference for enhancing the environmental monitoring quality of chemical fibre wastewater, compensating for the environmental monitoring errors, realizing the energy conservation and emission reduction of the chemical fibre industry.

## INTRODUCTION

The manufacturing of chemical fibre is an industry occupied in all kinds of processes, such as preparation of chemical fibre stock solution, polymerization, spinning, and after-process treatment. The application of chemical fibres, the main raw materials in the textile industry, has been transformed from the garment field into industrial fields, such as automobile, building, indoor and outdoor building materials, and labour protection. The overall chemical fibre output in Mainland China presented a rising trend from 2014 to 2020, reaching the peak output of approximately 61,680,000 tons in 2020. As water resources are used in the chemical fibre production process in quantity, sewage and wastewater are discharged on a large scale. Chemical fibre wastewater refers to all kinds of wastewater generated in the chemical fibre production process. It includes polyethene terephthalate (PET), purified terephthalic acid (PTA), and cotton pump black liquor. Others may also contain viscose, strong acid, strong base, aldehydes, cyanide, and benzenes. All of which can easily generate toxic actions on microorganisms.

China is the largest producing and exporting country of textile products in the world. It also has the most complete global textile industrial chain. In the face of downturn pressure in the adjustment phase, the Chinese chemical fibre industry maintains a slow-growth trend. This output growth is supported by positive national measures facilitating high-quality development and accompanied by the aggravated environmental protection pressure. On November 10, 2020, the Ministry of Ecological Environment of China released Self-Monitoring Technology Guidelines for Pollution Sources-Chemical Fibres Manufacturing Industry. This guideline presents the general requirements for self-monitoring of pollutant discharging units in the chemical fibre manufacturing industry and the basic contents and procedures for the monitoring scheme, information records, and reports. The pollutant discharging units in the chemical fibre manufacturing industry should conduct individual monitoring of water and air pollutants, discharged noise, and impact on surrounding environmental quality in the production and operation phase. The monitoring facilities should also be set and maintained, and monitoring data

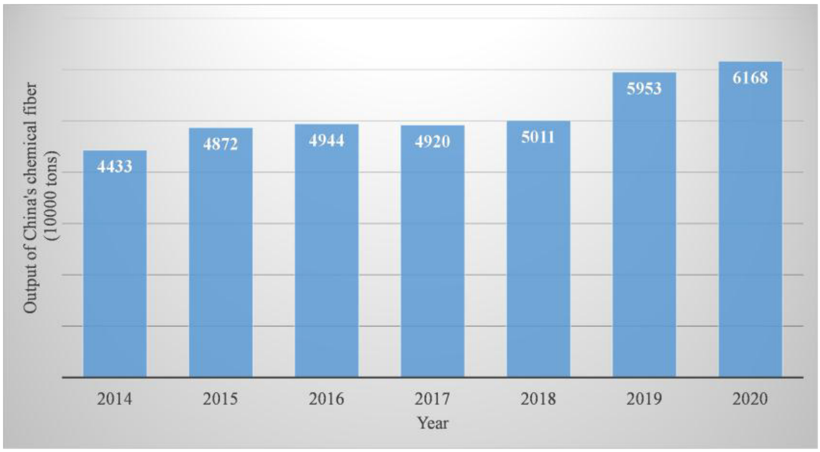


Fig. 1: The output of chemical fibre in China during 2014-2020.

should be recorded and saved for reference. Finally, the measurement uncertainty should be investigated to verify the monitoring system and the quality of monitoring data. These methods can help chemical fibre wastewater treatment and environmental protection.

## OVERVIEW OF THE STUDY AREA

The wastewater treatment technology has originated from municipal sewage treatment and has been continuously developing for over 100 years. It is the result brought by the industrial revolution and urbanization. The serious pollution triggered by the chemical fibre manufacturing industry in China is in urgent need of solutions. Various chemical fibre manufacturing plants are dispersedly distributed in the country's vast territory, so the difficulty in wastewater treatment is large. Concerning the hazards of wastewater discharged by chemical enterprises and the uncertainty problem of the monitoring equipment, Orhon et al. (1994) evaluated the pollution degrees generated by household and industrial sources in Istanbul metropolitan area. They compared the pollutant load in Marmara Sea with the pollutants discharged by Istanbul metropolitan area. Aleksandra et al. (2009) deemed that the waste materials of pump mills were harmful to the surrounding environment. They analysed the environmental research results regarding the impact of surface water in pump mills. They also evaluated the production process factors following the wastewater concentration and distribution in water circulation. Escher et al. (2011) believed that industrial wastewater discharge contained many hazardous chemical substances, which entered the water environment through urban runoffs and agricultural production. The extensive distribution of organic micropollutants in the water channel imposed harm to aquatic organisms and formed further pressure on residential drinking water. In Pakistan, Nasir et al. (2012) found that the industrial sector was damaging surface water and underground water qualities. The wastewater caused surface water and underground water pollution and endangered biodiversity, human health, and other ecosystems. Verma et al. (2012) deemed that the textile industry was one of the industries with the highest chemical intensity worldwide. Many complicated chemical pollutants would be generated in different textile processing links through wastewater. If directly discharged into the environment, they would trigger various undesirable changes and impact the current ecological status. Lambert et al. (2015) stated that most chemical plants would generate wastewater during the production process and the environmental hazards of wastewater were always the focus of attention. The potential safety hazards in the wastewater treatment would also lead to major risks. Shirkhanloo et al. (2015) investigated the heavy metal pollution in water, soil, and vegetables on a farm nearby the southern oil refinery in Teheran, Iran. The results showed that heavy metal content was high in industrial wastewater, which resulted in severe environmental pollution. Tayeb et al. (2015) showed that most municipal wastewaters were discharged into the sea without treatment in Algeria. They probed the influences of industrial production on dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), and pH value in Oran Bay of Algeria. The results showed that the concentration of petroleum and grease released into the biological network in industrial production generated a large ecological impact. Wei et al. (2019) evaluated the environmental impact of industrial upgrading in Guangdong Province since 2008 using the panel data of prefecture-level cities. The results showed that the industrial upgrading in Pearl River Delta led to minor water body pollution because the transfer of water-polluting industries was forbidden. As for the research on the environmental monitoring uncertainty, Batley (1999) investigated environmental monitoring programs. They found that the final analysis could be implemented only when the data quality was comprehensively guaranteed. Thus, the quality of environmental monitoring data was extremely significant. Rocke et al. (2003) deemed that the analytical chemical measurement in environmental monitoring relied upon the evaluation of measuring errors, and the measurement uncertainty should be quantified. They proposed a double-component error model to realize such goals. Conti et al. (2005) described a more detailed uncertainty theory to discuss the problems related to instrumental analysis and uncertainty correction. Nezhikhovskii (2009) introduced various aspects of measurement uncertainty in an analytical laboratory in Russia. They compared the differences in Russia from other countries in the estimation and application of measurement uncertainty. Boon et al. (2010) thought that the measurement method used to characterize environmental pollution was uncertain, which was generated by the field sampling and chemical analysis.

Based on the above literature, the development of the chemical fibre manufacturing industry plays an irreplaceable role in the socio-economic growth of various countries. However, the environmental disruption it causes cannot be underestimated, and treatment and discharge of polluted water sources require adequate attention. Especially in China, a developing country, the national policies focusing on the environmental monitoring field have been frequently formulated. In turn, the overall environmental monitoring industry has a steady growth, which somehow mitigates the environmental pollution. Overall, the monitoring data of related industries and enterprises cannot accurately reflect the current environmental status or provide a reliable basis for environmental governance work. In this study, the hazards caused by the wastewater discharge of chemical fibre manufacturing enterprises are analysed. A case analysis is conducted using the wastewater data of a chemical fibre manufacturing enterprise in Jilin Province. The uncertainty measurement is carried out for the automatic water quality monitoring instrument after the chemical fibre wastewater treatment. The sources of uncertainty components are analysed, the standard uncertainty is evaluated, and the uncertainty component with the greatest influence on the measurement result is determined and well-controlled. This study can serve as a reference for further monitoring of the main factors in chemical fibre wastewater. The findings can help guarantee the accuracy and precision of water quality monitoring results.

## HAZARDS OF CHEMICAL FIBRE WASTEWATER

### Polluting the Surrounding Environment

Chemical fibre wastewater contains many different pollutants, including phenols, organophosphorus, chlorine and different inorganic pollutants, organic and inorganic mixtures, solids, jellies and an oil slick. If their contents are not effectively reduced to below the national standard in the chemical fibre manufacturing process, they will result in irreversible and persistent environmental impact. Given their insufficient environmental awareness with ineffective monitoring measures, some chemical fibre manufacturing enterprises directly discharge the wastewater generated in the industrial production process into rivers, leading to water pollution in the surrounding area.

### Endangering Human Health

The chemical fibre wastewater pollution will directly affect human health. If the polluted water body is accidentally consumed through drinking water or food chains, the toxic substances will make the human body suffer from acute, chronic toxicity to different degrees. Other water bodies may also contain the corresponding chemical substances with carcinogenesis, which can endanger human health. The toxic organic matter in wastewater cannot be easily degraded. Once they are mixed with different bodies of water, they will exert an extremely destructive environmental impact. This situation can lead to cancer and influence human health through aquatic organisms.

### Destroying Biodiversity

The chemical fibre wastewater pollution can destroy the living space of organisms. Given that organic acids, alcohols, and epoxides are generated during the chemical fibre production, they will further experience oxidative decomposition reaction in water after being discharged. They will consume most of the dissolved oxygen in the water. In turn, they greatly affect the survival of aquatic animals and plants. The discharge of chemical fibre wastewater may also lead to a rise in the water temperature, unstable pH value, or excessive nutrient substances. All of which will threaten the growth of aquatic organisms. $NH_3$-N in wastewater will cause the eutrophication of water bodies, as it consumes more dissolved oxygen. It will destroy the aquatic environment and impede the safe growth of fish and other water organisms.

## MODEL PROFILE

Measurement uncertainty refers to a parameter related to the measurement result and is used to characterize the dispersity reasonably assigned to the measured values. It is mathematically expressed by standard deviation or multiple of standard deviation. The half-breadth of the confidence interval of a given probability can also be used. The measurement uncertainty reflects the experience accumulation and measurement quality and level for one type of factor. In the environmental monitoring measurement, the uncertainty is introduced to evaluate the measurement quality. A mathematical model can qualitatively and qualitatively analyze the source and components of uncertainty. Thus, it can appropriately express the measurement result through the combination and extension of uncertainty.

The focus of the uncertainty measurement of chemical fibre wastewater monitoring is the content of one element or chemical compound in the solution. The standard measurement methods mainly include titrimetry, colourimetry, and spectrophotometry. The measurement process mostly involves standard liquid preparation, mass measurement, and volume measurement. They mainly follow the principle of indirect measurement, where the measurement result is obtained by combining the instrument-measured value with a standard curve. In this study, a universal mathematical model is used to investigate the measurement uncertainty problem (Peng et al. 2009).

$$C(x) = \frac{f(Y) \times V}{M} \times \frac{P}{R} \times K \qquad \ldots(1)$$

Where $c(x)$ is the content of one element in the measured solution. $f(Y)$ denotes a concentration function, namely, the functional relationship between sample concentration and instrument response value. $v$ represents the volume of the measured solution. $M$ is the mass of the measured sample. $P$ is precision, expressing the precision influence generated in the operation process with a balance and measuring tool. $R$ is recovery, reflecting the loss of the measured solution or polluted factor. $K$ is the dilution ratio.

The fitting curve equations of standard liquid used by the measurement methods of pH, suspended solids, COD, $NH_3$-N, and total phosphorous (TP) in chemical fibre wastewater are simple linear regression equations. The combined measurement uncertainty is $u_c$, as expressed in Formula (2).

$$\frac{u_C^2}{C} = \left[\frac{u_{f(Y)}}{f(Y)}\right]^2 + \left[\frac{u_V}{V}\right]^2 + \left[\frac{u_M}{M}\right]^2 + \left[\frac{u_P}{P}\right]^2 + \left[\frac{u_R}{R}\right]^2 \qquad \ldots(2)$$

where $u_c$ is the combined measurement uncertainty and $u_{f(Y)}$ is the uncertainty of concentration function after the curve fitting. $u_V$, $u_M$, $u_P$ and $u_R$ are the uncertainties in the volume measurement, mass measurement, precision measurement, and recovery measurement, respectively. Following Formula (2), the relative measurement uncertainty $u_{crel}$ is extended and expressed, as seen in Formula (3).

$$u_{crel} = \sqrt{u_{f(y)rel}^2 + u_{Vrel}^2 + u_{Mrel}^2 + u_{Prel}^2 + u_{Rrel}^2} \qquad \ldots(3)$$

Where $u_{crel}$ is the combined relative measurement uncertainty. $U_{f(y)rel}$ is the relative uncertainty of the concentration function after the curve fitting. $u_{Vrel}$, $u_{Mrel}$, $u_{Prel}$ and $u_{Rrel}$ are the relative uncertainties in the volume measurement, mass measurement, precision measurement, and recovery measurement, respectively.

## CASE ANALYSIS

### Acquisition of Environmental Monitoring Data

A chemical fibre enterprise in Jilin City, Jilin Province, was taken as the research subject. Monitoring points were arranged at its spinning wastewater collection tank, esterification wastewater collection tank, and wastewater discharge outlet to monitor the pH value, COD, $NH_3$-N, and TP from December 3 and 4, 2020 (for two consecutive days, four times per day). The monitoring results at the chemical wastewater discharge outlet are shown in Table 1.

Table 1 gives the discharge concentrations of COD, $NH_3$-N, TP, and the pH value during the monitoring period. These monitoring results were from the general wastewater discharge outlet of the studied enterprise. They all conformed to the standard discharge limits specified in Table 1 of the *Emission Standard of Pollutants for Petroleum Chemistry Industry* (GB31571-2015).

### Uncertainty Evaluation of Monitoring Results

The monitoring was already completed in terms of work, and the monitoring results were qualified. However, this mean value method failed to evaluate the indications of

Table 1: Monitoring results at chemical fibre wastewater discharge outlet.

| Monitoring item | 1st time | 2nd time | 3rd time | 4th time | 5th time | 6th time | 7th time | 8th time | Mean value and range | Standard present value |
|---|---|---|---|---|---|---|---|---|---|---|
| pH value | 8.10 | 8.15 | 8.08 | 8.25 | 7.95 | 7.99 | 7.86 | 7.97 | 7.86–8.25 | 6–9 |
| COD | 33 | 30 | 30 | 32 | 31 | 34 | 33 | 36 | 32 | 70 |
| NH3-N | 2.10 | 1.84 | 1.77 | 1.76 | 1.11 | 1.09 | 0.88 | 0.90 | 1.43 | 8.0 |
| TP | 0.28 | 0.26 | 0.26 | 0.26 | 0.52 | 0.54 | 0.56 | 0.50 | 0.40 | 1 |

the measurement results. It did not analyze the whole measurement process or provide quality evaluation and improvement suggestions for the enterprise or monitoring unit. Thus, analysis methods were also used. The main detecting instruments are shown in Table 2.

According to Formulas (1) and (2) of the universal model, the monitoring methods and detecting instruments of the above four monitoring quantities were combined to carry out the uncertainty source analysis and uncertainty calculation of each component. The calculation results of combined uncertainty are shown in Table 3.

The extended uncertainty is calculated using Formula (3), as given in Table 4.

The pH value of the aqueous solution is measured using the selected methods and instruments. Uncertainties caused by pH meter, repetition of measurement results, and standard buffer solution used by calibration instrument influence the uncertainty measurement. With the development of instrument technology, the temperature and humidity in environmental factors can be included in the instrumental factors. Human factors and instrument variability are embodied in the repetition of measurement results. The main uncertainty sources are listed for the following measurements. For COD: standard potassium dichromate solution, calibration of standard ammonium ferrous sulphate solution, volume difference of ferrous ammonium sulphate consumed by the titration blank and water sample, measurement of the water sample, the molar mass of oxygen, and repetition of sample measurement. For $NH_3$-N: dilution of standard $NH_3$-N solution, sampling, curve fitting, and measurement repetition. For TP: preparation of the standard stock phosphorous solution, dilution of stock solution to a working solution, standard curve fitting, and repetition of sample measurement. In general, the uncertainty triggered by the repetition of sample measures is too large, which is

Table 2: Analysis methods and detecting instruments used for five monitoring quantities of chemical fibre wastewater.

| S/N | Monitoring type | Item name | Basis for the analysis method | Main detecting instrument |
|---|---|---|---|---|
| 1 | Wastewater | pH value | Water Quality-Determination of pH value-Glass Electrode Method (GB6920-1986) | pH meter |
| 2 | | COD | Water Quality-Determination of pH value-Dichromate Method (HJ828-2017) | Standard COD digester |
| 3 | | $NH_3$-N | Water Quality-Determination of pH value-Nessler's Reagent Spectrophotometry (HJ535-2009) | Ultraviolet and visible spectrophotometer |
| 4 | | TP | Water Quality-Determination of pH value-Ammonium Molybdate Spectrophotometric Method (GB/T 11893-1989) | Ultraviolent and visible spectrophotometer |

Table 3: Measurement uncertainties.

| Monitoring item | | Component uncertainty | | | | | Relative combined uncertainty (%) |
|---|---|---|---|---|---|---|---|
| | | Uncertainty of concentration function | Uncertainty in volume measurement | Uncertainty in mass measurement | Uncertainty in precision measurement | Uncertainty in recovery measurement | |
| pH value | Standard (mol/L) | $3.18 \times 10^{-9}$ | — | — | $2.62 \times 10^{-9}$ | — | 4.19 |
| | Relative | 0.0230 | — | — | 0.0350 | — | |
| COD | Standard (mg/L) | — | 0.0314 | 0.018 | 2.07 | — | 6.39 |
| | Relative | $1.77 \times 10^{-3}$ | $2.18 \times 10^{-3}$ | $9.00 \times 10^{-4}$ | $6.38 \times 10^{-2}$ | $4.42 \times 10^{-4}$ | |
| $NH_3$-N | Standard (mg/L) | $3.24 \times 10^{-4}$ | $3.13 \times 10^{-2}$ | — | 1.43 | — | 33.8 |
| | Relative | $5.22 \times 10^{-3}$ | $6.26 \times 10^{-3}$ | — | 0.338 | $5.34 \times 10^{-3}$ | |
| TP | Relative | $1.79 \times 10^{-3}$ | $5.20 \times 10^{-3}$ | — | 0.359 | $1.42 \times 10^{-3}$ | 35.9 |

Table 4: Extended uncertainty.

| Monitoring item | Extended relative uncertainty ($k$ = 2; %) | Extended uncertainty | Representation of measurement result ($k$ = 2) |
|---|---|---|---|
| pH value | 8.38 | $(8.36–9.88) \times 10^{-9}$ mol/L | 8.04 ± 0.04 |
| COD | 12.78 | 2.07 mg/L | (32 ± 2.07) mg/L |
| $NH_3$-N | 67.6 | 0.97 mg/L | (1.43 ± 0.97) mg/L |
| TP | 71.8 | 0.29 mg/L | (0.40 ± 0.29) mg/L |

mainly ascribed to a long measurement period and different matter contents in samples.

## POLICY SUGGESTIONS

### Perfecting the Chemical Fibre Production Process

The production procedures of the chemical fibre manufacturing industry are complicated. The wastewater quality components are also varied. Thus, the most effective technical measures should be taken to conduct wastewater treatment and transform toxic substances into harmless components for recycling. In this way, the waste discharge in chemical fibre production can be reduced, and the environmental protection effect of chemical fibre manufacturing can be improved. The management of chemical fibre wastewater treatment process and technology should be strengthened to reduce the discharge of chemical fibre wastewater and mitigate environmental pollution. The quality of water treatment should also be improved to facilitate the progress of petrochemical fibre manufacturing. The most suitable wastewater treatment process and technical measures should be selected and used. For example, the physiochemical method can be used to treat chemical fibre wastewater. It removes oil droplets, suspended matters, and bacteria through de-oiling, air flotation, adsorption, and membrane separation. In turn, the wastewater quality can reach the related quality standards and be used as circulating water or boiler water in chemical fibre production. Ultimately, the discharge of chemical fibre wastewater can be reduced.

### Improving the Wastewater Treatment Process

The differences between chemical fibre products and treatment methods are prominently manifested by the quantity difference of pollutant types. Therefore, the promotion and application should be reinforced in the chemical fibre manufacturing process. With continuous social progress, the chemical fibre wastewater treatment measures should be constantly studied, innovated, strengthened, and improved. In this way, the economic benefit of chemical fibre production can be elevated to the maximum extent, and the wastewater discharge cost and the water quality standard can be improved. For instance, the advanced oxidation technology can be used to decompose organic matters that can be hardly degraded by macromolecules through the chain reaction of free radicals under high-temperature, high-pressure, and catalytic conditions. When the membrane separation technology is used to separate the components after the chemical fibre wastewater treatment, the obtained by-product can generate profit. The treatment standards of chemical fibre wastewater have been continuously improved. Product safety and environmental protection are boosted with the direct implementation of oil-water separation, improvement of chemical fibre wastewater treatment quality, application of various membrane materials, and development of new nanofilm separation technologies.

### Strengthening the Development of the Environmental Monitoring Industry of Wastewater

The government should strengthen the policy inclination to the environmental monitoring field in the chemical industry. They can establish a national network focusing on air environmental monitoring, water quality monitoring, and pollution source monitoring. They should support the market for monitoring equipment to maintain the overall growth of the environmental monitoring industry. The enterprises dedicated to environmental pollution control should be encouraged to propose technological innovations for environmental monitoring. These innovations should emphasize remote and intelligent sewage pollution source analysis, transregional transmission, scientific decision-making, and precision regulation. The current technologies, such as miniaturized technology of environmental analytical instruments, online analysis technology of comprehensive water toxicity, and volatile organic compound online monitoring technology, should also be strengthened.

### Enhancing the Virtual Instrument R&D for Environmental Monitoring

Virtual instruments have low cost, a wide range of applications, and strong repeatability. Thus, they are easier to use and more suitable for special environments, such as field operation, than traditional instruments. They can save materials and improve working efficiency if used to simulate the measured data. Accordingly, the extensive application of virtual instruments in environmental monitoring should be strengthened. The uncertainties of their components and their overall uncertainties should be determined and evaluated. For some components exceeding the related errors, they should be reasonably debugged and verified to ensure the smooth test and the accuracy of the environmental monitoring results.

## CONCLUSIONS

The chemical fibre industry is the subject of China's consumer goods industry and is critical to national economic growth. It is a typical representative labour-intensive industry with high energy consumption and high pollution. The environmental monitoring of pollutants generated in the chemical fibre production should be strengthened, and the monitoring quality should be improved. These actions are significant to relieve the pressure triggered by economic growth to resource supply and facilitate efficient utilization and recycling of resources. In this study, the hazard types of wastewater generated in the chemical fibre production were determined. The wastewater monitoring uncertainties of a chemical fibre industry in Jilin City, Jilin Province were measured using an environmental monitoring uncertainty model. The literature describes the chemical fibre industry as a labour-intensive industry with high energy consumption, which leads to severe environmental pollution. This claim is supported by the following findings in the current study: The main hazard types of chemical fibre wastewater are "polluting the surrounding environment, endangering human health, and destroying biodiversity". The monitoring quality reliability of the extended uncertainty model for the pH value, COD, $NH_3$-N, and TP used in this case is superior to the direct chemical numerical detection quality. Thus, perfecting the chemical fibre production process, improving the wastewater treatment process, strengthening the development of the environmental monitoring industry of wastewater, and enhancing the virtual instrument R&D for environmental monitoring are proposed. In the future, an in-depth study can be implemented from the following aspects: a comprehensive evaluation of environmental monitoring indices for the chemical fibre industry, optimization of environmental monitoring uncertainty model, technical index standard of environmental monitoring instruments, exploration of energy conservation, and emission reduction paths for the chemical fibre industry.

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## REFERENCES

Aleksandra Lewkiewicz-Małysa and Elżbieta Konopka 2009. Evaluation of waters environment hazard by pulp-mill liquors. Polish Journal of Chemical Technology, 10(4): 15-19.

Batley, G. E. 1999. Quality assurance in environmental monitoring. Marine Pollution Bulletin, 39(1-12): 23-31.

Boon, K.A., Taylor, P. D. and Ramsey, M. H. 2010. Estimating and optimising analytical and sampling uncertainty in environmental investigations: Application and evaluation. Geostandards and Geoanalytical Research, 31(3): 237-249.

Conti, M.E., Muse, J.O. and Mecozzi, M. 2005. Uncertainty in environmental analysis: Theory and laboratory studies. International Journal of Risk Assessment and Management, 5(2): 311-335.

Escher, B. and Leusch, F. 2011. Bioanalytical tools for safe water supplies: using cellular response to show toxicity effect. Water, 21: 31-33.

Lambert, P. G. and Woodward, J. L. 2015. Learning from events: major process safety incidents from wastewater in process chemical plants, or take care of your wastewater or it will take care of you. Process Safety Progress, 30(1): 45-51.

Peng, L.M., Zhi, H., Liang, Y. and Zhong, D.L. 2009. Mathematical model for general use in evaluation of uncertainty of some commonly used analytical methods. Physical Testing and Chemical Analysis (Part B: Chemical Analysis), 45(5): 558-45.

Nasir, A., Arslan, C., Khan, M. A., Nazir, N., Awan, U. K., Ali, M. A. and Waqas, U. 2012. Industrial wastewater management in district Gujranwala of Pakistan-current status and future suggestions. Pakistan Journal of Agricultural Sciences, 49(1): 79-85.

Nezhikhovskii, G. R. 2009. Measurement uncertainty in quantitative chemical analysis: problems of the transition period. Inorganic Materials, 45(14): 1643-1647.

Orhon, D., Uslu, O., Meriç S., Salihoglu, I. and Filibeli, A. 1994. Wastewater management for Istanbul: basis for treatment and disposal. Environmental Pollution, 84(2): 167-78.

Rocke, D. M., Durbin, B., Wilson, M. and Kahn, H.D. 2003. Modeling uncertainty in the measurement of low-level analytes in environmental analysis. Ecotoxicology and Environmental Safety, 56(1): 78-92.

Shirkhanloo, H., Mirzahosseini, S.A.H., Shirkhanloo, N., Moussavi-Najarkola, S.A. and Farahani, H. 2015. The evaluation and determination of heavy metals pollution in edible vegetables, water and soil in the south of Tehran province by gis. Archives of Environmental Protection, 41(2): 64-74.

Tayeb, A., Chellali, M. R., Hamou, A. and Debbah, S. 2015. Impact of urban and industrial effluents on the coastal marine environment in Oran, Algeria. Marine Pollution Bulletin, 98(1-2): 281-288.

Verma, A. K., Dash, R. R. and Bhunia, P. 2012. A review on chemical coagulation/flocculation technologies for removal of colour from textile wastewaters. Journal of Environmental Management, 93(1): 154-168.

Wei, D., Liu, Y. and Zhang, N. 2019. Does industry upgrade transfer pollution: evidence from a natural experiment of Guangdong province in China. Journal of Cleaner Production, 229(20): 902-910.