EVALUATION OF TREATMENT TECHNOLOGY TO IMPROVE THE QUALITY OF UNDERGROUND WASTEWATER AT VINACOMIN HA LAM COAL JOINT STOCK COMPANY, QUANG NINH BY ULTRA FILTRATION (UF)

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ABSTRACT

Water pollution is a problem that receives a lot of attention from the community and society. Especially, wastewater from the exploitation of assets, going through treatment systems is a problem that needs to be solved. This study aimed to evaluate the wastewater treatment system of VINACOMIN coal joint-stock company Ha Lam, Quang Ninh by ultrafiltration membrane (UF). The survey was carried out over the period from May 2020 to December 2020, at the end of the dry season and the middle of the rainy season, focused on wastewater generated by coal extraction, production, and processing in areas of the company. The research shows that the company's underground wastewater was polluted with the same pollution as most of the wastewater from pit mining. After treatment, it met the permissible standards according to column B QCVN 40:2015/BTNMT on industrial wastewater with values such as pH, total suspended solids (TSS), metals and heavy metals such as Fe, Mn, Pb... which were qualified, within the permitted threshold and allowed to be discharged into the environment.

ĐÁNH GIÁ CÔNG NGHỆ XỬ LÝ NÂNG CAO CHẤT LƯỢNG NƯỚC THẢI HẦM LÒ TẠI CÔNG TY CỔ PHẦN THAN VINACOMIN HÀ LẦM, QUẢNG NINH BẰNG MÀNG LỌC ULTRA FILTRATION (UF)

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TỪ KHÓA

Khai thác than
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Nước thải

TÓM TẮT

Ô nhiễm nguồn nước đã và đang là vấn đề nhận được rất nhiều sự quan tâm của cộng đồng và xã hội. Điều tra, khảo sát, thu thập dữ liệu về nguồn nước thải sau khai thác của mỏ than hiện nay là vấn đề cấp thiết, được các nhà khoa học và quản lý quan tâm. Mục tiêu bài báo đánh giá hiện trạng chất lượng nước thải của công ty cổ phần than VINACOMIN Hà Lầm, Quảng Ninh bằng màng lọc ultra filtration. Điều tra được thực hiện trong khoảng thời gian từ tháng 5 năm 2020 đến tháng 12 năm 2020, vào cuối mùa khô và giữa mùa mưa, tập trung nghiên cứu về nước thải phát sinh từ quá trình khai thác, sản xuất và chế biến than tại các khu vực của Công ty. Qua nghiên cứu cho thấy nước thải hầm lò của công ty có mức độ ô nhiễm tương tự như phần lớn nước thải khai thác hầm lò. Qua hệ thống màng lọc sau xử lý, nước thải ra môi trường đạt tiêu chuẩn cho phép theo cột B QCVN 40:2015/BTNMT về nước thải công nghiệp; các giá trị như pH, tổng chất rắn lơ lửng (TSS), các kim loại và kim loại nặng như Fe, Mn,... đều nằm trong ngưỡng cho phép và được phép thải ra ngoài môi trường.

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1. Introduction

Coal is one of the non-renewable resources that play an important role in industrial development in the world and Vietnam. It is estimated that our country has more than 10.5 billion tons, of which the exploitable reserve is 3.5 billion tons, 3/4 of which is coal [1]. However, in addition to the achievements we have got, we also face many environmental problems. During the mining process for their benefit, people changed the surrounding environment. The main factor affecting the environment in the field of mines, landfills, toxic gases, dust, and wastewater... disrupting the balance of ecological conditions [2], [3] which has been formed for tens of millions of years, causing serious environmental pollution and an urgent social and political problem of the community. Mining often produces dust, wastewater in large quantities, polluting the air and water. In general, the extraction process is obsolete, without a dust collection system, at times, the dust content in the workplace is nine times higher than the permitted standard [4].

In Quang Ninh coal mines, there are two forms of exploitation: underground and open-pit mining, production is mainly pit mining, but during the extraction process, wastewater is one of the alarming environmental pollutants. The search for and choice of a solution to recirculate mine wastewater treatment for daily life and production is an important, urgent and appropriate factor that saves water resources and environmental protection [5]. When wastewater is used efficiently and sustainably, it will help improve the quality of the environment, reduce production costs without the need to buy water for domestic use, saving resources, increasing public income, creating a premise for the sustainable development of the coal industry in particular and the country's economy in general [6]. The study focuses on treatment technology to improve the quality of wastewater according to column B QCVN 40:2015/BTNMT [7] for industrial groundwater in Ha Lam Coal Joint Stock Company - VINACOMIN by UF membrane - Membrane ultrafiltration [8], [9]. The research aims to assess the current state of groundwater pollution and find ways to overcome and limit water pollution to contribute to ensuring the sustainable development of the mining sector, especially the coal mining industry in Quang Ninh.

2. Research methods

The survey was carried out over the period: from May 2020 to December 2020, at the end of the dry season and at the middle of the rainy season. The research focused on wastewater generated by coal extraction, production and processing in areas of Ha Lam Coal Joint Stock Company - VINACOMIN.

2.1. Retrospective methods

Related documents were collected, classified, and processed to selectively inherit the results of existing research. In addition, Ha Lam Coal Company's mining and water use documents were also collected.

2.2. Method of analysis by experts

The study brought together scientific experts from scientific institutions. A number of system designers, engineers who manage the wastewater treatment system, managers and directors were directly interviewed.

2.3. Method of sampling river water and streams for analysis: according to TCVN 6663-6: 2008 [2]

The total number of water samples for analysis was measured by the author at the outlet of the site, at an altitude of + 28m above sea level. Samples were collected before and after the water treatment. Samples were taken 4 times, on 5 May, 5 August, 15 October, and 11 December 2020. For each sample, 12 parameters were analyzed. Analysis sheet included such parameters as pH, TSS, BOD5, COD, total Fe, Mn, Pb, Cu, Cd, total P, mineral oil and Total Coliform [3].

2.4. Data processing method

Biological statistical methods, Excel 2010 software were used to assess the reliability of results.

Water sample analysis methods: surface water quality parameters were determined according to the guidance of national standards or corresponding analytical standards of international organisations [3]. The applicable standards include TCVN 6492: 2011; TCVN 6202: 2008; TCVN 7324: 2004; TCVN 6625-2000; TCVN 6637: 2000; TCVN 6658: 2000; TCVN 6180: 1996; TCVN 6224: 1996; TCVN 6002: 1995; SMEWW 5210D: 2012; EPA.200.8: 2012; EPA 8270D... [4]. Water samples were analyzed in the environmental analysis laboratory (VILAS 995 - VIMCERTS 112) - Institute of Environmental Engineering and Technology, results were checked at the Institute of Chemistry of Vietnam.

3. Results and discussion

3.1. Assessment of the mining industry's activities in the Ha Lam coal mines area

Ha Lam mine is located in an area with a convenient transport network. The 18A road through Ha Lam Coal Company connecting the provinces of Hai Phong, Hai Duong, Hanoi is an important route. There is also an 18B road, transporting coal from the field to the Nam Cau Trang coal refinery and the port of Cua Luc [1], (see figure 1). The location of the coal mine is near the sea, with roads suitable for operation and transport in large quantities.

Figure 1. *Ha Lam coal mine and location of the sampling*

The topography of the Ha Lam coal mine includes the exploitation layers that tend to be lower from the North to the South. The surface water is mainly rain water and is poured into streams. There is a network of rivers and streams that flows towards the river Ha Lam, with the width from 2 m to 3 m; the flow rate is:

Qmin = 0.1 l/s (dry season)

Qmax = 14.5 l/s (rain season)

3.2. Analysis and evaluation of the treatment technology to improve the quality of wastewater from the pit at the coal company of VINACOMIN

3.2.1. Current state of waste water before treatment

Through the actual sampling of investigations and analyses, ground wastewater is mainly generated by groundwater, and surface water is absorbed and a part of water for production is degraded at the same time as the overflow of rainwater that is also harvested by the company. This source of water was divided into two parts, a part was treated and then released into the environment, and the other part is treated and distributed as industrial water such as irrigation, road, washing. The elevation of the coal dump was determined + 65m above sea level. The elevation of the water discharge pipe at the coal storage was determined + 28m above sea level. On average, the discharge water got the highest discharge volume of 840 m^3/day. The coal storage area is large without any vegetation around the dump with no roof in the machinery operating areas, so if it rains, the amount of grease and solids will be carried away by water, if not stored properly. In the composition of solids, it has fine coal particles, mineral particles, suspended clay, metals such as iron and other dissolved substances. Therefore, the company has designed a collection and treatment system together with wastewater from coal mines at the location + 28m above sea level, the wastewater treatment system is right next to the Ha Lam coal mine. The results of the sampling and analysis process for untreated groundwater samples from the Ha Lam coal mine, from May 2020 to December 2020, up to 4 monitoring and analysis times are presented in Table 1.

Table 1. *Results of the analysis of water samples before going through the UF treatment system*

Index	Unit	Results of analysis					Vietnamese standards 40-2015
		05/05	05/08	15/10	11/12	Average	
pH	-	4	4	4.5	4.5	4.25	5.5 – 9
TSS	mg/l	389	489	559	700	534.2	100
Pb	mg/l	0.006	0.006	0.006	0.006	0.006	0.5
Cu	mg/l	0.46	0.46	0.46	0.46	0.46	2
Total Fe	mg/l	1.1	1.1	2.1	2.1	1.6	5
Cd	mg/l	KPH	KPH	-	0.02	0.02	0.1
Mn	mg/l	4	4	-	-	4	1
COD	mg/l			154	250	202	150
BOD_5	mg/l	-	-	18	20	19	50
Σ P	mg/l	-	-	0.3	0.3	0.3	6
Oil (Grease)	mg/l	-	-	16.2	18.2	17.2	10
Coliform	MPN/100	1800	1800	1800	1800	1800	5000

(Monitoring analytical data, KPH: not detected; '-': Do not analyse results)

The results of the follow-up studies in Table 1 show that the underground waste water of Ha Lam Coal Joint Stock Company - VINACOMIN before treatment had a low pH value (ranging from 4- 4.5). The concentrations of suspended solids (TSS) in mines were quite high; all exceeded the permitted limit by 4 to 7 times; mineral oil and grease exceeded the limit of 1.6 to 1.8 times; Mn content fluctuated 4 mg/l, exceeding the permissible limit by 4 times; Fe content ranged from 1.1 ÷ 2.1 mg/l in the lower of the permissible limit; COD content was 5 ÷ 8 times higher than the permitted regulation. In addition, heavy metals, including Pb, Cd, total P, coliform, BOD5 in the company's groundwater were all below the standard COD index, all of which were high with a specific characteristic. The wastewater of the Ha Lam coal mine is different from other mines because it has a relatively high amount of saline ions, namely Cl ion - which is due to the location of the mine near salted groundwater in the estuary sea. It can be observed that groundwater from Ha

Lam coal mine were polluted and required treatment and management measures before being released to the environment in order to avoid environmental pollution.

Aware of the need and urgency of waste water treatment, the company built wastewater collection areas and post-exploitation wastewater treatment areas and mine wastewater treatment process. For rainwater: in order to limit the rain water flow in the mining area, discharge, affecting production and causing environmental pollution, the company designed to dig ditches to catch water with stimulus with width x height of 700 x 1000 mm, then pump into the good system to separate suspended solids, check quality to meet the new standards before released into the environment. In addition, stormwater runoff will be collected at the same time as sewage from the pits for treatment.

For groundwater: All groundwater is collected in a storage well on site -51 with a capacity of more than 1000 m^3 to clear raw impurities and large scale particles to create favorable conditions for the next treatment steps, then ground pumping +28 flow in the open brick system of length x width x depth: 20 x 0.7 x 1.0 (m) flow in the company's groundwater treatment system.

Wastewater was pumped from the reservoir at site -51 to the site treatment system +28, where wastewater flows through a 3-compartment neutralization tank with a capacity of 350 m3. Here, substances like a transparent milky lime solution, NaOH solution, CAP, PAA coagulation solution, $Ca(OCl)_2$ chemical bactericide were pumped by the metering pump system to neutralize the container in proportion concentration. The chemicals were blended evenly with the waste water through an aeration system placed at the inlet of the feedwater. Waste water after mixing with chemicals continued to be evenly distributed over the tank section thanks to a water distribution system near the tank. The particles of suspended sediments, after flocculation form large-sized floc, will gradually settle to the bottom of the tank. In the opposite direction of the input flow, the clear water will be poured over the surface water collection trough to the end of the tank. The water after being treated through a neutralization tank is relatively satisfactory in terms of pH, clarity, bacterial cleanliness, oxidation and is pumped continuously by pressure pump alternative to a filter system comprising 12 specialized pressure filters with a capacity of 10 m^3/ tank. The filter materials of this special filtering equipment include: 0.4 ÷ 0.8 mm quartz sand, Fe and Mn filter material, 0.9 ÷ 1.2 mm buffer material. In the filtration process, the residue is retained on the surface of the material layer of the UF filter [5], the filter pressure exceeds the safe value, so that it is necessary to rinse the filter.

The filling process is carried out on the basis of the principle that the water is pushed from bottom to top thanks to the pressure of the filter pump combined with the air compressor to push the residue on the surface of the layer of filter material according to the descaling path. The backwash time depends on the dirt level of the UF filter material layer. System diagram is illustrated in Figure 2.

The process of rinsing down water is carried out according to the principle that the water is brought from top to bottom by pump pressure to push the residue to the bottom of the layer of the filter material along the waste discharge road. After filtering the water through a group of 12 pressure filters, sediment discharges (during washing and filtration) and sludges into neutral treatment tanks are regularly pumped into the concentrated sludge tank, then loaded and converted into landfill. Moreover, it can be downloaded into the environment or into the Ha Lam stream itself.

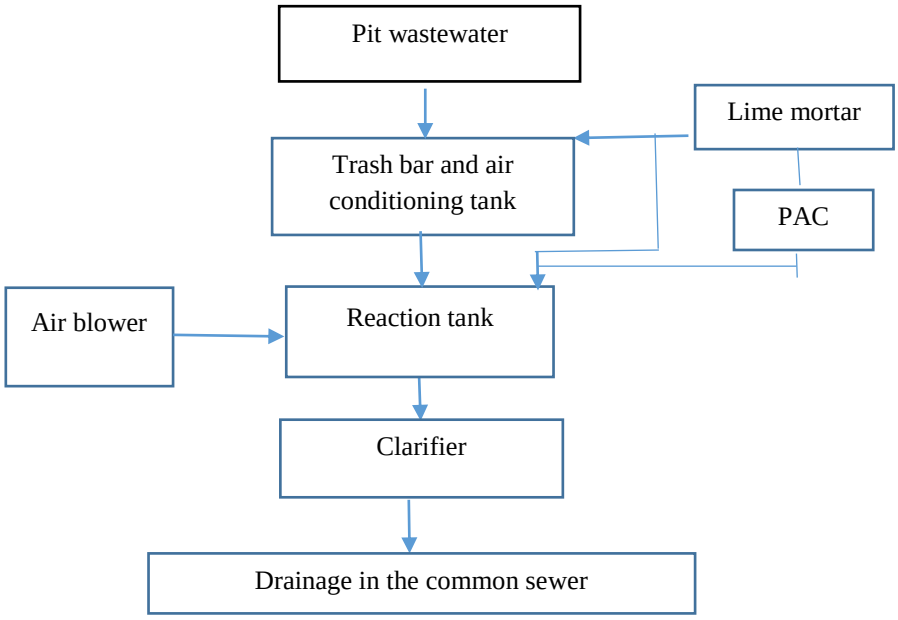

Figure 2. *Diagram of the wastewater treatment system* [1]

3.2.2. Result of the groundwater quality of the Ha Lam coal mine after treatment

Table 2. *The results of the water sample analysis after going through the UF treatment system*

Index	Unit	Results of analysis					QCVN 40-2015
		05/05	05/08	15/10	11/12	Average	
pH	-	6.7	7	7.5	7	7.05	5.5 – 9
TSS	mg/l	80	80	80	90	82.5	100
Pb	mg/l	0.005	0.005	0.005	0.005	0.005	0.5
Cu	mg/l	0.38	0.38	0.38	0.38	0.38	2
Total Fe	mg/l	0.9	0.9	0.9	0.5	0.8	5
Cd	mg/l	KPH	KPH	-	0.01	0.01	0.1
Mn	mg/l	1	0.5	-	-	0.75	1
COD	mg/l	-	-	33	30	31.5	150
BOD_5	mg/l	-	-	16.7	18	17.35	50
Σ P	mg/l	-	-	0.28	0.28	0.28	6
Oil (Grease)	mg/l	-	-	2.1	2.2	2.15	10
Coliform	MPN/100	1900	1900	1700	1700	1800	5000

(Monitoring analytical data, KPH: not detected; '-': Do not analyse results)

The results in Table 2 show that after treatment, the groundwater of the Ha Lam mine met the permissible standard according to column B QCVN 40: 2015/BTNMT on industrial wastewater. pH values, total solids, suspended metals (TSS), metals and heavy metals such as Fe, Mn, Pb... all meet the requirements, are within the limit of the threshold. Parameters such as TSS, Total Fe, Mn, COD reduce sharply and achieve high yield. In particular, the average TSS content decreased from 534.25 mg/l to 82.5 mg/l (low to 451.75 mg/l); the total Fe content decreased by 2 times from 1.6 to 0.8 mg/l; the Mn content decreased by 4 to 0.75 mg/l (decrease by 5.3 times); COD content decreased from 202 mg/l to 31.5 mg/l (down 170.5 mg/l). From there, we can see that Ha Lam Company's treatment technology has achieved very high efficiency. After being treated, the mine wastewater will be discharged into the environment ie Ha Lam stream, and then into the sea (Ha Lam stream is a natural flow, in the rainy season, water from hills and streams is

also a source of wastewater drainage from people's daily life and production activities in the area, directly or indirectly through surface water in the area). In the current period and following the regional development planning, the source water is not used. For daily life, agricultural production, and aquaculture, the treatment of farm wastewater according to Ha Lam flow does not affect the flow).

3.2.3. Comment on the technology of groundwater treatment with UF filter

The use and recirculation of sewage from the pits has been seriously studied and applied by the coal companies in Quang Ninh. During the company's coal mine wastewater research, it was found that the Ha Lam coal company's groundwater had the general characteristics of the underground wastewater in Quang Ninh province in particular and in the country in general. However, there is a very different character from wastewater of other companies [1] that the salinity of wastewater is quite high, wastewater from mines and farm fields has high salinity, or the high concentration of Cl- ions because the company's operating area is near the estuary sea.UF membrane (Ultra Filtration), also known as ultrafiltration membrane of porous cable fibers, each membrane fiber is tubular in shape, white, when filtered allows the water to go from outside into the tube through the water flow pressure, when we plug one end of the tube or bend it in a (U) shape. Under pressure, water flow will flow through the capillaries about -> 0.1 ~ 0.001 micrometer (μm) in size [2].

* Use of a UF filter system:

As mentioned above, we can see that the UF membrane is both economical and effective in the treatment, meeting the recirculation requirements and the effluent standards of the plant's output. Therefore, UF membrane technology should be applied more to the to the filter system of Ha Lam coal company. In addition, treated waste water can be used as water for bathing, washing and living for workers. Thus, when the UF filtering system is put into this system, the reused water will be filtered again more carefully; the quality of the treated water is also more assured, saving freshwater.

4. Conclusion

Based on the analysis and assessment, it appears that the groundwater of the Ha Lam Coal Joint Stock Company - VINACOMIN before treatment had a low pH value (4 to 4.5); suspended solids (TSS) concentrations of mines were quite high, all exceeding the permitted limit by 4-7 times; the mineral oil and fat exceeded the limit from 1.6 to 1.8 times; the Mn content fluctuated 4 mg/l, exceeding the permissible limit by 4 times; the Fe content varied from 1.1 ÷ 2.1 mg/l in the lower of the permissible limit; COD content was 5 ÷ 8 times higher than the permitted regulation. In addition, heavy metals including Pb, Cd, total P, coliform, BOD5 content in the company's wastewater were below the standard.

After being treated with the UF system, the waste water met the permitted standards in accordance with column B QCVN 40:2015/BTNMT on industrial waste water [7]. The values including pH, total suspended solids (TSS), metals and heavy metals such as Fe, Mn, Pb... all met the requirements, and allowed to be discharged into the environment. Parameters such as TSS, Total Fe, Mn, COD reduced sharply. Specifically, the average content of TSS decreased from 534.25 mg/l to 82.5 mg/l (down 451.75mg/l); the total Fe content decreased by 2 times from 1.6 to 0.8 mg/l; the Mn content decreased from 4 to 0.75mg/l (decreased by 5.3 times); the COD content decreased from 202 mg/l to 31.5 mg/l (down 170.5 mg/l). From there, it shows that Ha Lam Company's UF membrane treatment technology is very effective.

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