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REMOVAL OF ORGANIC POLLUTANTS FROM WASTEWATERS OF COAL PROCESSING INDUSTRY WITH KOSOVA BASIN COAL AS ADSORBENT

Adsorption of phenols, oil and greases, and suspended matters by activated carbon and fly ash from wastewaters of the Kosova Basin coal processing (coal gasification and coal drying plant) was investigated. The removal of the above compounds has been found to be concentration and time dependent. The results achieved show that fly ash has the best adsorption properties for oil and greases and suspended matters, whereas activated carbon has the highest efficiency in removing phenols from wastewaters.

1. INTRODUCTION

In recent years, both the scientists and ordinary people have become increasingly aware of the problems of energy. In most countries coal is the most abundant fossil fuel and it will be constantly converted into energy by direct combustion in steam boilers.

A report by the World Coal Study (1980) stressed that *coal will have to supply between one-half and two-thirds of the additional energy needed by the World* and that *to achieve this goal world coal production will have to increase 2.5 to 3 times, and the world trade in steam coal will have to grov 10 to 15 times above 1979 levels* [1]. This study described coal as the bridge to future energy systems while stressing world coal prospects, environmental problems, resources, reserves and production technologies, investments, and energy projections.

Coal gasification has been regarded as a promising technology in the production of the gaseous fuels needed to supplementing the dwindling reserves of petroleum and natural gas. SINGER et al. [2] classified the organic constituents of coal gasification wastewater into six major groups: monohydric phenols, dihydric phenols, polycyclic hydroxy compounds, monocyclic, *n*-aromatic and aliphatic acids.

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Of these compounds, the phenolic components, mainly phenol, methylphenol, and C-2 phenols, constitute 60 to 80% of the organic content of these wastewaters.

There are three major sources introducing organics to water [3], i.e.,

1. Natural organic materials which undergo dissolution.

2. Compounds formed in the course of chemical reactions that occur during disinfection, treatment, and distribution of water.

3. Contaminants originating due to commercial activiy.

In general, the efforts to eliminate the industrial contaminants have been focused mainly on reducing the input of compounds from the latter two cathegories of sources.

Organics from waters can be eliminated by using some unit processes such as reverse osmosis, adsorption, oxidation, and coagulation.

Adsorption at various adsorbents (activated carbon, silica, bentonite, fly ash, etc) can be regarded as an important process in controlling the pollution extent caused by organic pollutants and metallic species of industrial effluents. Generally, the adsorption ability is proportional to specific surface area of adsorbent, specific surface area being the part of the total surface available for adsorption [4].

This study describes an investigation of wastewates of a complex coal processing industry in Kosova, Yugoslavia. This complex of the coal processing industry consists of electric power plants (of about 2000 MW capacity), gasification plant, nitrogen fertilizer plants, and a coal drying plant.

Unfavourable impacts of the Kosova industrial coal complex on the sorrounding atmosphere and waters are as follows:

1. Aerosols in the form of coal dust. They were found to be the significant pollutants from the coal-handling operation.

2. Aerosols carrying PAHs.

3. Organic compounds in the ambient air, including aliphatic and aromatic hydrocarbons and their oxygen-, sulfur-, and nitrogen-containing derivatives.

4. Industrial wastewaters containing a large quantity of phenolic compounds, oil and greases, and total suspended matters discharged to the nearest Sitnica river.

This work is part of a programme to identify and quantify parameters affecting the adsorption of phenols, oils and greases by activated carbon and ather adsorbents and to apply these findings to treatment practice. The adsorption properties of coal (chemically treated with HNO_3, H_2SO_4, HCl, and NaOH) and its fly ash were compared with those of activiated carbon, and then their adsorption abilities were tested for removal of phenol contained in phenolic standard solutions and phenolic wastewaters produced in gasification and coal drying plants.

2.. EXPERIMENTAL

Coal used as adsorbent for removal of phenols, oil and greases, and total suspended solids was a lignite taken from a superficially exploited mine in KSA Kosova. To assess the adsorbent properties of this coal and its fly ash, we prepared

standard solutions of phenols and treated them with nitrated and sulfonated lignite and with lignite treated with hydrochloric acid and sodium hydroxide as well as with fly ash.

The industrial wastewaters that were treated with chemically treated coal, fly ash, and activated carbon were taken from the Kosova Coal Basin processing industry (gasification plant and drying plant).

The treatment of the standard phenolic solution and industrial wastewater was done by mixing the adsorbent and water effluents in a constant mass ratio by means of a magnetic stirrer. For each gram of adsorbent, 100 cm^3 of standard solutions or wastewater was used. The reaction time of adsorption was constant (2 h) for all experiments. After 2 h, the mixture of adsorbents and water solution was filtered and in the filtrate the concentrations of phenols, oil and greases, total suspended solids, volatile (organic) suspended solids, and fixed (inorganic) suspended solids were determined using standard methods.

The phenolic concentrations were determined spectrophotometrically (a Perkin–Elmer Hitachi 200 UV-VIS spectrophotometer). Oil and greases were determined by Soxhlet extraction method. Total suspended solids were determined by Soxhlet extraction method. Total suspended solids were analysed for volatile (organic) matter and fixed suspended matter (inorganic in an ash form).

Adsorbents used for removal of organic pollutants from wastewaters of coal processing industry were a lignite tipe coal, its fly ash, and activated carbon.

3. RESULTS AND DISCUSSION

The purpose of this research was to investigate the possibilities of removing some of the organic pollutants present in effluent from coal processing industry by means of adsorption on powdered activated carbon and coal fly ash.

Samples of wastewater effluents were collected in coal gasification and drying plants and the determinations of pH, total suspended solids, COD, phenols, volatile suspended solids, fixed suspended solids, and oil and greases were performed (tab. 1).

Table 1

Some characteristics of wastewater effluents from coal processing industry

Parameters	Gasification plant	Coal drying plant
pH	9.91	7.95
Total suspended solids, g/m^3	352.5	690.0
Volatile suspended solids (organic), g/m^3	13.9	12.8
Fixed suspended solids (inorganic), g/m^3	338.6	677.2
COD, g/m^3	6048.0	3248.64
Phenols, g/m^3	90.5	6.62
Oil and greases, g/m^3	250.0	180.0

In order to compare the adsorption abilities of various adsorbents, we tested the removal of phenols by chemically treated coal (nitrated, sulfonated, HCl–NaOH treated) and fly ash (tab. 2). From the experimental results (see tab. 2) it can be seen that there existed a considerable difference in the sorption abilities of different adsorbents. The efficiencies of the adsorption described increased according to the following series: fly ash, treated coal, activated carbon and were dependent on the nature of the adsorbent, reaction time, and concentration of phenol.

Table 2

Removal of phenols by coal, ash and activated carbon

Phenol concentration g/m^3	Adsorbent	Phenol concentration after treatment	Percent removal of phenol
Standard solution, 10	Coal nitrated with 0.01 M HNO_3	5.08	49.20
Standard solution, 21.4	Coal nitrated with 0.01 M HNO_3	11.40	46.73
Standard solution, 21.4	Coal sulfonated with 0.1 M H_2SO_4	12.20	43.00
Standard solution, 5.83	Coal treated with 1 M HCl and 0.1 M NaOH	1.97	66.21
Gasification plant, 61.0	C-activated	0.28	99.54
Gasification plant, 61.0	Nitrated coal	31.0	49.27
Coal drying plant, 13.52	Nitrated coal	5.86	56.51
Coal drying plant, 13.52	Sulfonated coal	5.44	59.76
Coal drying plant, 13.52	Coal treated with HCl–NaOH	4.44	67.16

Very effective removal of phenols, oil and greases, total suspended solids, volatile (organic) suspended solids, and fixed (inorganic) suspended solids was achieved during their adsorption on the activated carbon and fly ash. The concentrations of the compouds present in the influent (before treatment) and effluent (after adsorption) were shown in tabs. 3 and 4.

Table 3

Treatment of coal gasification wastewater with activated carbon and fly ash

Parameter	Concentration (g/m^3)		Percent removal	Fly ash treatment	Percent removal
	Initial	active carbon treatment			
Total suspension solids	352.5	9.0	97.45	13.0	96.31
Volatile (organic)	13.9	5.2	62.59	6.2	55.40
Fixed (inorganic)	338.6	3.8	98.88	6.8	97.99
COD	6048.0	3663	39.43	2714	55.13
Phenols	90.5	27.0	70.17	72.5	19.89
Oil and greases	250.0	30.0	88.00	50.0	80.00

Table 4

Treatment of coal drying wastewater with active carbon and fly ash

Parameter	Concentration (g/m^3)		Percent removal	Fly ash treatment	Percent removal
	Initial	active carbon treatment			
Total suspension solids	690	1.71	99.75	30	95.65
Volatile (organic)	12.8	0.73	99.81	1.43	88.83
Fixed (inorganic)	677.2	0.97	99.86	28.57	95.78
COD	3248	352	89.15	312.0	90.4
Phenols	6.62	0.28	95.77	3.3	50.16
Oil and greases	180	60.0	66.70	80.0	55.56

On the basis of results obtained the following conclusions could be drawn:

1. There was a significant difference in the abilities of different adsorbents to adsorb phenols, oil and greases, and total suspended solids.

2. Very effective removal of phenols, total suspended solids (volatile-organic and fixed-inorganic), and COD was achieved when an intensive mixing of water solutions and adsorbents occurred.

The contact time required to achieve the equilibrium between organic compounds adsorbed and those persisting in water solution appears to be mass ratio dependent. A 2 h contact time seems to be an optimum required for approximately 80–90% phenol, oil and greases, and total suspended solids' adsorption.

REFERENCES

[1] KAGEY B. T., WIXON B. G., *Applied Environmental Geochemistry*, Academic Press, London 1983, pp. 463–480.
[2] PFEFFER J. T., Journal WPCF, Vol. 55 (1983), No. 10, pp. 1263–1270.
[3] MONTGOMERY J. M., *Water Treatment, Principles and Design*, John Wiley and Sons, New York 1985.
[4] WEBER W. J., Jr., Jour. Pure and Appl. Chem., 37, 375.
[5] PANDY K. K., PRASAD G., SING V. N., Water Res., 19, (1985), 869.

USUWANIE ZANIECZYSZCZEŃ ORGANICZNYCH ZE ŚCIEKÓW POWSTAJĄCYCH PODCZAS PRZERÓBKI WĘGLA ZA POMOCĄ ADSORBENTA WĘGLOWEGO

Badano adsorpcję fenolu, oleju i smarów oraz zawiesin zawartych w ściekach z Zagłębia Kosowskiego na węglu i popiele lotnym. Stwierdzono, że usuwanie wymienionych związków zależy od ich stężenia i czasu trwania procesu. Otrzymane wyniki wykazały, że popiół lotny jest najlepszym adsorbentem oleju i smarów oraz zawiesin, węgiel aktywny natomiast najefektywniej adsorbuje fenole.

УДАЛЕНИЕ ОРГАНИЧЕСКИХ ЗАГРЯЗНЕНИЙ ИЗ СТОЧНЫХ ВОД, ВОЗНИКАЮЩИХ ВО ВРЕМЯ ПЕРЕРАБОТКИ УГЛЯ С ПОМОЩЬЮ УГОЛЬНОГО АДСОРБЕНТА

Исследована адсорбция фенола, масла и смазок, а также суспензий, содержащихся в сточных водах, происходящих из Косовского бассейна, на угле и летучей золе. Установили, что удаление вышеперечисленных соединений зависит от их концентрации и времени продолжения процесса. Полученные результаты обнаружили, что летучая зола является самым лучшим адсорбентом масла и смазок, а также суспензий, зато активный уголь наиболее эффективно адсорбирует фенолы.