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Adsorption properties of modified ash sludge waste for heavy metal ion removal from aqueous solutions

Modifikatsiyalangan kulli loyqa chiqindilarining suvli eritmalardan og‘ir metall ionlarini adsorbsiyalash xususiyatlari

Адсорбционные свойства модифицированных золошламовых отходов по отношению к ионам тяжёлых металлов из водных растворов

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ENGLISH

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Abstract. This study investigates the sorption properties of ash sludge waste from the Takhiatash Thermal Power Plant before and after alkaline-acid activation. Modification increased the specific surface area and porosity of the material, enhancing its capacity to adsorb heavy metal ions. The adsorption of Pb^{2+}, Cu^{2+}, Ni^{2+}, and Mn^{2+} ions was analyzed using the Langmuir and Dubinin-Radushkevich models. The highest sorption capacities were obtained for Pb^{2+} (71.94 mg/g) and Cu^{2+} (52.36 mg/g). These findings demonstrate the potential of modified ash sludge waste for removing heavy metals from wastewater.

Keywords: ash sludge waste, alkaline-acid activation, heavy metals, sorption capacity, textural characteristics, Langmuir model, Dubinin-Radushkevich equation

O‘ZBEKCHA

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Annotatsiya. Maqolada Taxiatosh IES kulli loyqa chiqindilarini ishqoriy-kislotali faollashtirishdan oldin va keyin sorbsion xususiyatlarini o‘rganish natijalari keltirilgan. Modifikatsiya natijasida materiallarning solishtirma sirt maydoni va g‘ovakliligi ortib, og‘ir metall ionlarini adsorbsiyalash qobiliyati yaxshilandi. Langmuir va Dubinin - Radushkevich modellari asosida Pb^{2+}, Cu^{2+}, Ni^{2+} va Mn^{2+} ionlarining adsorbsiyasi tahlil qilindi. Eng yuqori sorbsiya sig‘imi Pb^{2+} (71,94 mg/g) va Cu^{2+} (52,36 mg/g) ionlari uchun aniqlandi. Olingan natijalar modifikatsiyalangan kulli loyqa chiqindilaridan oqova suvlarni og‘ir metallardan tozalashda foydalanish imkoniyatini ko‘rsatadi.

Kalit so‘zlar: kulli loyqa chiqindi, ishqoriy-kislotali faollashuvi, og‘ir metallar, sorbsiya qobiliyati, tekstura xarakteristikalari, Lengmyur modeli, Dubinin-Radushkevich tenglamasi

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РУССКИЙ

НАЖИМОВА Нурсулу Базарбаевна[1,*], БАЛТАБАЕВ Дамир Онгарбай угли[1], СЕЙДУЛЛАЕВА Назокат Алламбергеновна[1], НАЖИМОВА Гулжахан Базарбаевна[2]
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Аннотация. В статье представлены результаты изучения сорбционных свойств золошламовых отходов Тахиаташской ТЭС до и после щелочно-кислотной активации. В результате модификации увеличились удельная поверхность и пористость материалов, улучшилась их способность адсорбировать ионы тяжёлых металлов. Адсорбция ионов Pb^{2+}, Cu^{2+}, Ni^{2+} и Mn^{2+} проанализирована на основе моделей Ленгмюра и Дубинина–Радушкевича. Наибольшая сорбционная ёмкость установлена для ионов Pb^{2+} (71,94 мг/г) и Cu^{2+} (52,36 мг/г). Полученные результаты показывают возможность использования модифицированных золошламовых отходов для очистки сточных вод от тяжёлых металлов.

Ключевые слова: золошламовые отходы, щелочно-кислотная активация, тяжёлые металлы, сорбционная способность, текстурные характеристики, модель Ленгмюра, уравнение Дубинина–Радушкевича

1. KIRISH
Introduction

Ko‘mir yoqilishi natijasida hosil bo‘ladigan kulli loyqa chiqindilar tarkibida turli metall oksidlari va boshqa mineral komponentlar mavjud bo‘lib, ularning to‘planishi ekologik muammolarni keltirib chiqaradi. Ushbu chiqindilarni qayta ishlash atrof-muhitga salbiy ta’sirni kamaytirish hamda oqova suvlarni tozalash uchun samarali adsorbentlar olish imkonini beradi. Kulli chiqindilarning g‘ovakli tuzilishi va kimyoviy modifikatsiyalash imkoniyati ularni og‘ir metall ionlari va boshqa ifloslantiruvchilarni adsorbsiyalashda istiqbolli xomashyo sifatida qo‘llashga asos bo‘ladi. Shu sababli kulli loyqa chiqindilarni ishqoriy-kislotali faollashtirish orqali ularning sorbsion xususiyatlarini yaxshilash va oqova suvlarni tozalash samaradorligini oshirish muhim ilmiy-amaliy ahamiyatga ega.

Ishqor (natriy gidroksidi NaOH) va kislota (HNO_3) bilan ishlov berish kulning sirt maydonini va faol guruhlarini oshirib, sorbsiya samaradorligini kuchaytiradi. Modifikatsiyalangan kulli loyqa chiqindilar Pb^{2+}, Zn^{2+}, As(V) ionlari hamda organik bo‘yoqlarni samarali olib tashlaydi. Koagulyatsiya va CO_2 karbonatsiyasi bilan birgalikda qo‘llanishi esa chiqindi suv va tutun gazlarini tozalash samaradorligini yanada oshiradi.

Shu nuqtai nazardan, kulli loyqa chiqindillarining teksturaviy xususiyatlari va ularning og‘ir metall ionlari adsorbsiyasiga ta’siri o‘rganiladi. Sirt maydoni, g‘ovaklik va g‘ovak taqsimotini baholash strukturaviy parametrlar bilan sorbsiya qobiliyati o‘rtasidagi bog‘liqlikni aniqlash imkonini beradi. Adsorbsion faollikni baholash uchun Pb^{2+}, Cu^{2+}, Ni^{2+} va Mn^{2+} kationlari tanlandi. Ularning sorbsion xatti-harakati materiallarning selektivligi va samaradorligini hamda sirt bilan o‘zaro ta’sir mexanizmlarini aniqlashga xizmat qiladi.

Adsorbsion faollikni aniqlash uchun Pb^{2+}, Cu^{2+}, Ni^{2+} va Mn^{2+} kationlari o‘rganildi, chunki ular ko‘pincha energiya va sanoat korxonalari oqava suvlarida uchraydi. Ushbu ionlar zaharliligi, gidratsiya radiusi va kompleks hosil qilish qobiliyati bilan farqlanadi, bu bizga ionning tabiati va modifikatsiyalangan kulli loyqa chiqindillari yuzasida sorbsiya samaradorligi o‘rtasidagi munosabatni o‘rnatishga imkon beradi.

2. TAJRIBA BO‘LIMI
Experimental

Tadqiqot ob’ektlari Taxiatosh IES da ko‘mir (KCh) va tabiiy gazni (GCh) yoqish paytida hosil bo‘lgan uchuvchi kul va shlak chiqindilari edi.

Kislotali faollashtirish, uning reaktivligi va adsorbsion xususiyatlarini yaxshilash uchun kul loyqa chiqindilarining tuzilishi va kimyoviy tarkibini maxsus o‘zgartirish uchun ishlatilgan. Ishqor va kislota bilan ketma-ket ishlov berish aralashmalarni olib tashladi, govokli tuzilish hosil qildi va o‘ziga xos sirt maydonini oshirdi.

Adsorbsion tajribalar Pb^{2+}, Cu^{2+}, Ni^{2+} va Mn^{2+} tuzlarining eritmalari yordamida o‘tkazildi.

Cu^{2+} adsorbsiyasi ammiak eritmasida (pH 9-10) hosil bo‘lgan $[Cu(NH_3)_4]^{2+}$ kompleksi yordamida spektrofotometrik tarzda aniqlandi. Rang intensivligi UV-5100 spektrofotometri yordamida 600-620 nm da o‘lchandi.

Pb^{2+} adsorbsiyasi ditizon yordamida spektrofotometrik tarzda aniqlandi, u 510-520 nm yutilish maksimal bilan barqaror qizil kompleks hosil qiladi. Ishchi eritma $Pb(CH_3COO)_2$ dan ozgina kislotali eritmada (pH 4-5) tayyorlangan.

Mn^{2+} adsorbsiyasi kompleksometrik titrlash orqali aniqlandi.

EDTA bilan, reaktsiyaning yakuniy nuqtasini qayd qilish uchun indikator yordamida.

Ni^{2+} ammoniy asetat tamponida (pH 9-10) dimetilglioksim (DMG) yordamida aniqlandi. Rangli Ni^{2+}-DMG kompleksi 445-470nm da spektrofotometrik tarzda tahlil qilindi.

3. NATIJALAR VA MUHOKAMA
Results and discussion

Qoraqalpog‘iston Respublikasi hududidagi Taxiatosh Issiqlik elektr stansiyasida ko‘mir va tabiiy gazni yoqish jarayonida hosil bo‘lgan kulli loyqa chiqindilarning ishqoriy-kislotali faollashuvidan oldin va keyin sorbsion xususiyatlarini o‘rganish natijalari keltirilgan. Materiallarning morfologiyasi, fazaviy tarkibi va tekstura xususiyatlarining har tomonlama tahlili o‘tkazildi.

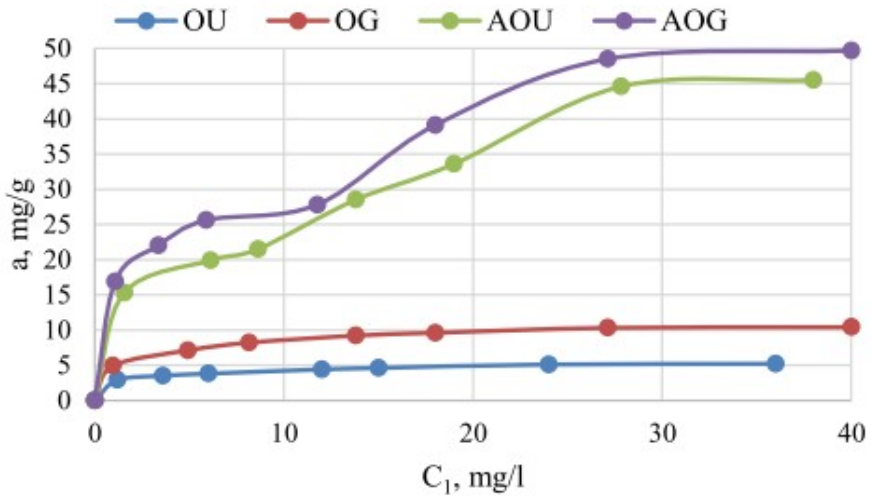
Aniqlanishicha, modifikatsiya solishtirma sirt maydonining oshishiga, g‘ovakli strukturaning rivojlanishiga va faol joylar sonining ko‘payishiga yordam beradi, bu esa adsorbsiya qobiliyatining sezilarli darajada oshishiga olib keladi.

Adsorbsion xususiyatlar Pb^{2+}, Cu^{2+}, Ni^{2+} va Mn^{2+} ionlari uchun Langmuir va Dubinin-Radushkevich izotermik modellari yordamida o‘rganildi. Faollashtirilgan namunalar Pb^{2+} (71,94 mg/g gacha) va Cu^{2+} (52,36 mg/g gacha) uchun eng yuqori sorbsiya qobiliyatini ko‘rsatdi, Ni^{2+} va Mn^{2+} qiymatlari esa pastroq edi, bu ularning gidratsiya radiusi va kompleks hosil qilish qobiliyatidagi farqlar bilan izohlanadi.

Faollashtirish natijasida adsorbsiya energiyasining ortishi sorbent va og‘ir metall kationlari o‘rtasidagi o‘zaro ta’sir kuchayganini ko‘rsatadi.

Ishqoriy-kislotali ishlov berish kulli loyqa chiqindillarining sorbsion faolligini oshirib, ularni oqava suvlarni tozalashda samarali adsorbentga aylantiradi.

Faollashgan kulli loyqa chiqindillarining sorbsion faolligi Pb^{2+}, Cu^{2+}, Ni^{2+} va Mn^{2+} ionlari orqali aniqlanadi. Natijalar faollashtirilgan namunalar asl materiallarga nisbatan yuqori adsorbsion qobiliyatga ega ekanini ko‘rsatdi. Pb^{2+} uchun maksimal sig‘im FGCh da 49,7 mg/g, FKCh da 45,5 mg/g bo‘lib, bu faol markazlar soni va teksturaning yaxshilanganini tasdiqlaydi.

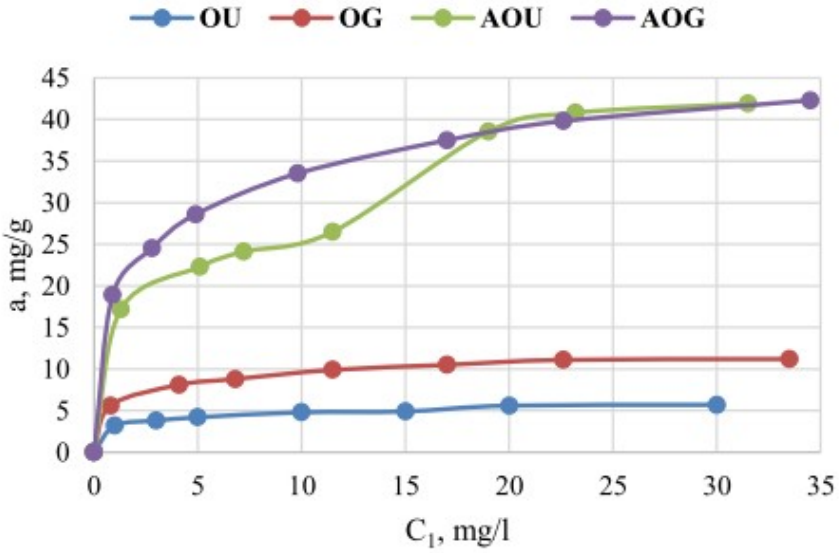


1-rasm. Namunalardagi Pb^{2+} ionlarining adsorbsion izotermalari / **Fig. 1.** Adsorption isotherms of Pb^{2+} ions on the samples

Faollashtirilgan va boshlang‘ich materiallar o‘rtasidagi adsorbsion xususiyatlardagi farqlar ishqoriy-kislota faollashtirish natijasida g‘ovaklik va faol markazlar sonining ortishi bilan bog‘liq bo‘lib, bu Pb^{2+} sorbsiya samaradorligini oshiradi.

Cu^{2+} adsorbsion izotermlari to‘yingan fizik adsorbsiyaga xos shaklga ega, ammo Pb^{2+} bilan solishtirganda sezilarli darajada past sorbsiya qobiliyatini namoyish etadi. Eng yuqori adsorbsiya faollashtirilgan namunalarda, ayniqsa FGCh da kuzatiladi.

Pb^{2+} dan farqli o‘laroq, Cu^{2+} adsorbsiyasi past konsentratsiyalarda sekinroq oshadi, bu ion radiuslari va sorbsiya mexanizmlaridagi farqlarga bog‘liq.



2-rasm. Namunalardagi Cu^{2+} ionlarining adsorbsion izotermalari / **Fig. 2.** Adsorption isotherms of Cu^{2+} ions on the samples

4. XULOSA

Conclusion

O‘tkazilgan tadqiqotlar shuni ko‘rsatdiki, Taxiatosh IES da ko‘mir va tabiiy gazni yoqish jarayonida hosil bo‘ladigan kulli loyqa chiqindilarning ishqoriy-kislotali faollashtirish ularning tuzilishini sezilarli darajada o‘zgartiradi va adsorbsion xususiyatlarini sezilarli darajada yaxshilaydi.

Faollashtirilgan namunalar (FKCh va FGCh), ayniqsa Pb^{2+} va Cu^{2+} ionlari uchun sezilarli darajada yuqori sorbsiya qobiliyatini ko‘rsatdi. Maksimal adsorbsiya qobiliyati FKCh da Pb^{2+} uchun 71,94 mg/g ga va Cu^{2+} uchun 52,36 mg/g ga yetdi, bu ularning sirtdagi kislorod o‘z ichiga olgan funktsional guruhlarga yuqori yaqinligi bilan izohlanadi. Ni^{2+} va Mn^{2+} uchun adsorbsion sig‘imi ularning kattaroq gidratlangan radiuslari va zaif kompleks hosil qilish qobiliyati tufayli past edi.

DECLARATIONS

Declarations

Author contributions *CRediT*

Conceptualization; Methodology; Investigation; Data curation; Writing – original draft; Writing – review & editing. All authors have read and agreed to the published version of the manuscript.

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Not applicable. This study did not involve humans, animals or other regulated materials.

Informed consent

Not applicable.

Data availability statement

All data supporting the findings of this study are included in the article.

Conflict of interest

The authors declare no conflict of interest.

Generative AI disclosure

Not used.

ADABIYOTLAR RO‘YXATI

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