Journal of Molecular Liquids 215 (2016) 565–595

Contents lists available at ScienceDirect

Journal of Molecular Liquids

journal homepage: www.elsevier.com/locate/molliq

Review

Removal of anionic pollutants from liquids by biomass materials: A review

Xing Xu [a], Baoyu Gao [a,*], Bo Jin [b], Qinyan Yue [a]

[a] Key Laboratory of Water Pollution Control and Recycling (Shandong), School of Environmental Science and Engineering, Shandong University, Jinan 250100, PR China
[b] School of Chemical Engineering, The University of Adelaide, Adelaide, SA 5005, Australia

ARTICLE INFO

Article history:
Received 15 October 2015
Received in revised form 3 December 2015
Accepted 30 December 2015
Available online xxxx

Keywords:
Biomass materials
Anions
Sorption
Sorbent
Surface modification and activation

ABSTRACT

The industrialization development has delivered a number of anionic species (nitrate, nitrite, cyanide, phosphate, perchlorate, and fluoride), as well as anionic metal complexes (chromate, arsenate/arsenite, vanadate and selenate/selenite) into ecosystems, which have received increasing concerns of environmental and human health risks. Increasing R&D emphasis has been placed on the development of cost-effective treatment technologies to remove these anionic pollutants. Among the advanced treatment technologies, sorption process has offered significant advantages like availability, profitability, simplicity in operation and efficiency. To exploit and use a low cost and high efficiency sorbent is the center of an industrial process. We present the current state of research on the preparation and utilization of biomaterials based activated carbons/anion exchange resins for removal of various anions. We report activation methods, especially recent chemical technologies to functionalize surface characteristics, specificity and selectivity of the biomass materials, and to enhance their sorption capacities and rates. The sorption as well as recovery capacities of the biomass sorbents studied in laboratory scale and pilot plant systems are summarized. It is evident that these biomaterials based sorbents have shown significantly low costs and comparable sorption capacities for various anions as those of commercial sorbents; this makes the biomaterials promising for the development of technically and economically feasible technology for removal anionic pollutants.

Contents

* Corresponding author.
E-mail addresses: baoyugao_sdu@aliyun.com, bygao@sdu.edu.cn (B. Gao).

http://dx.doi.org/10.1016/j.molliq.2015.12.101
0167-7322/

1. Introduction

Increasing anionic pollutants discharged into ecosystems from industries have been concerned worldwide due to their significant risks for environment and human health [1–6]. These anionic pollutants, including common anionic species as well as some anionic metal complexes (Table 1), are considered as the important pollutants in most quality standards of water/wastewater [2,4,5,7]. A number of common anionic species, including nitrate, nitrite, cyanide, phosphate, perchlorate, and fluoride, get introduced to the aquatic streams by means of various industrial activities viz. mining, refining ores, fertilizer industries, tanneries, batteries, paper industries etc. [1]. Unlike organic pollutants, these anions occur naturally in rock-forming and ore minerals which are associated with soils, sediments and waters [8,9]. They can be considered as pollutants that affect human health and ecosystems if their concentrations reach certain levels. For example, nitrate and phosphate that concentrations exceed 0.5–1.0 mg/L will stimulate the organisms and algae growths in most ecosystems, which result in deterioration of water quality as well as detriments to fish and other aquatic life [10]. The presence of fluorine in drinking water, within permissible limits of 1.5 mg/L, is beneficial for the maintenance of healthy bones and teeth, while excessive intake of fluoride causes dental or skeletal fluorosis which is a chronic disease manifested by softening of bones and neurological damage in severe cases [9,11–13]. Perchlorate, a major groundwater contaminant that is derived mostly from anthropogenic activities, has been proved to inhibit iodide uptake by the thyroid gland; and in large doses, it has been linked to anemia and fetal brain damage [7,14,15].

In addition to these common anionic species, some metal pollutants (Cr, As and Se) existing as the anionic complexes species (chromate, vanadate, arsenate/arsenite and selenate/selenite) can cause severe impacts on the aquatic streams and human health even at trace levels [16–24]. Anthropogenic chromate, arsenate, vanadate, arsenite, selenate and selenite stems from industries such as smelting, insecticides, petroleum refinery, glass, electroplating, leather tanning, herbicides, paints and pigments, cement, preservations, textile, steel fabrication as

Table 1
Permissible limits and health effects of various anions species.

Anionic contaminant	Permissible limit for effluent discharge in China (mg/L)		Permissible limit for drinking surface water sources in China (mg/L)	Permissible limits in drinking water (mg/L)			Health and environmental hazards
	Industrial standards	Municipal wastewater treatment plant		China	EU	USA	
Nitrate	–	–	10	10	10	10	Nitrosoamine, methemoglobinemia, and eutrophication of the aquatic streams
Nitrite	–	–	–	–	–	1	Cyanosis among children and cancer of the alimentary canal
Cyanide		0.5	0.05	0.05	0.05	0.2	Rapid breading, neurological effects; thyroid effects and nerve damage
Phosphate	0.5	–	0.1	–	–	–	Eutrophication in near urban areas
Perchlorate	–	–	–	–	–	0.0245	Inhibiting iodide uptake by the thyroid gland; anemia and fetal brain damage
Fluoride	10	–	1.0	1.0	1.0	4.0	Skeletal and neurological damage
Chromate (Cr)	0.5	0.05	0.05	0.05	0.05	0.1	Suspected human carcinogen, producing lung tumors, allergic dermatitis
Arsenate (As)	0.5	0.1	0.05	0.01	0.01	0.05	Carcinogenic, producing liver tumors, skin and gastrointestinal effects
Selenate/ selenite (Se)	–	0.1	0.01	0.01	0.01	0.05	Degrading the water, causing deterioration and deformity in fish and wildlife
Vanadate (V)	–	–	0.05	–	–	–	Causing mutations and inducing alterations of metabolic functions