Utilization of bio ash -based adsorbent materials in wastewater treatment

Sari Kilpimaa[a], Ville Kuokkanen[a], Hanna Runtti[a], Toivo Kuokkanen[a], Jaakko Rämö[b] and Ulla Lassi[a,c]
[a]University of Oulu, Department of Chemistry, P.O.Box 3000, FIN-90014 University of Oulu
[b]Thule institute, P.O.Box 7300, FI-90014 University of Oulu, Finland
[c]Kokkola University Consortium Chydenius, Unit of Applied Chemistry, Talonpojankatu 2 B, FIN-67100 Kokkola

Utilization of gasification carbon residue

- Activated carbon is produced from fossil materials or biomass by:
  - Physical activation (e.g. CO_2)
  - Chemical activation (e.g. KOH, $FeCl_3$, $ZnCl_2$)
- Carbon residue, a by-product from wood gasification process, have to be utilized in order to reduce waste streams in gasification

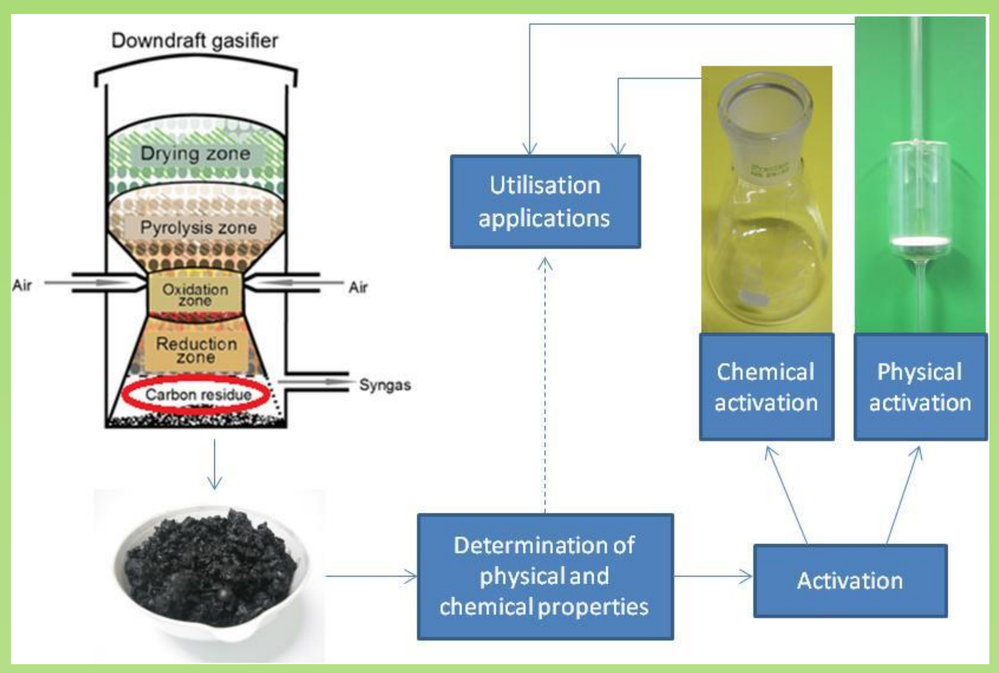

***Fig. 1**. Gasification carbon residue can be utilized directly or after modification e.g. as an adsorbent.*

Experimental and results

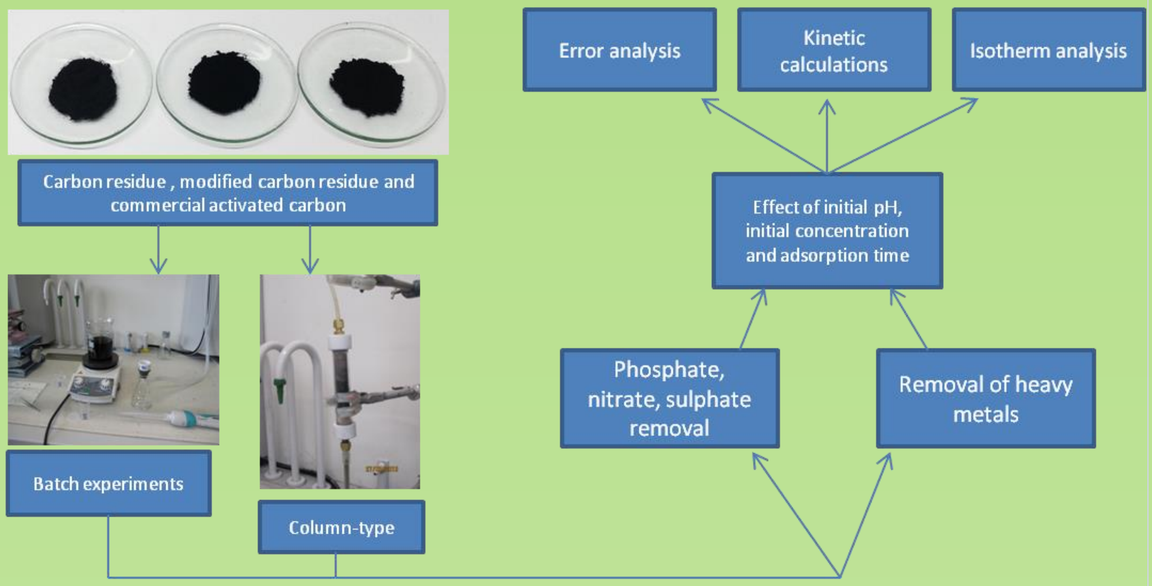

***Fig. 2**. Adsorption experiments for cations and anions removal.*

- Modification enhances adsorption capacity
- Adsorption capacity is better for modified carbon residue as compared with commercial activated carbon in the cases of phosphate and metal removal

Acknowledgements

This study has been performed with financial support of the EU/InterregNord/HighBio2 and EAKR/SULKA projects.

Publications

Kilpimaa S, Kuokkanen T, Lassi U (2011) Physical and chemical properties of wood ash from burning and gasification processes, *The Journal of Solid Waste Technology and Management*, Proceedings in ICSW 2011: 879-887.
Kilpimaa S, Kuokkanen T, Lassi U (2011) Chemical studies for utilisation of bioashes. Biomass gasification to heat, electricity and biofuels : HighBio project publication, (Eds. U. Lassi and B. Wikman): 81-87.
Kilpimaa S, Runtti H, Lassi U, Kuokkanen T (2012) Chemical activation of gasification carbon residue for phosphate removal, *Porous Media and its applications in Science, Engineering and Industry*, AIP Conference Proceedings 2012: 293-298.
Kilpimaa S, Kuokkanen T, Lassi U (2013) Characterization and Utilization Potential of Wood Ash from Combustion Process and Carbon Residue from Gasification Process, *BioResources* 8(1): 1011-1027.
Kilpimaa S, Lassi U, Kuokkanen T (2013) Chemical and physical activation of gasification carbon residue: adsorption studies. Biomass to energy and chemicals, HighBio2 Project Publication, (Eds. U. Lassi, H. Lempiäinen and B. Wikman): 85-92.
Kilpimaa S, Runtti H, Kangas T, Lassi U, Kuokkanen T (2014) Removal of phosphate and nitrate over a modified carbon residue from biomass gasification, In press *Chemical Engineering Research and Design*.

Contact information

Sari Kilpimaa, Ph.D student, sari.kilpimaa@oulu.fi, +358 50 428 8295
Hanna Runtti, Ph.D student, hanna.runtti@oulu.fi, +358 50 562 8369

Utilization of granulated bio-ash -based (from burning process) symbiotic products

The RAE-project strives to enhance the utilization of bio-ashes formed in the Oulu area by developing new granulated bio-ash -based "symbiotic pellets" for different applications. By mixing other industrial by-products (such as steel slags, see ***Fig. 3***) with bio-ashes, symbiotic pellets with new properties and utilization possibilities are obtained. While some of these eco- and material efficient products can be used as fertilizer or road and building construction material (larger pellets in ***Fig. 3***), using them as adsorbent material for wastewater treatment (smaller pellets in ***Fig. 3***) is a new feasible application. One new idea presented here is to use granulated symbiotic by-products as forest and agricultural fertilizer after enrichment through sorption of run-off nutrients (P & N) from e.g. peat bog drainage water.

***Fig. 3**. From left to right: bio-ash, steel slag and small- and large-sized symbiosis pellets containing bio-ash and steel slag.*

Experimental and results

- Batch adsorption experiments (light shaking, 24 h)
- All experiments were triplicated and showed good repeatability (slag additions were found to clearly enhance repeatability)
- The effect of different symbiosis pellet composition (all granules were filtered to a diameter of 5.6-6.73 mm) on phosphate removal efficiency was studied using various L/S-ratios (liquid/solid)
- It was found that adding steel slag to bio-ash granules significantly enhances the phosphate removal capacity of the granules (***Fig. 4***)
- The results also showed that the dissolution of chemical elements from the granules was significantly decreased by slag additions and the granules were clearly harder and stronger

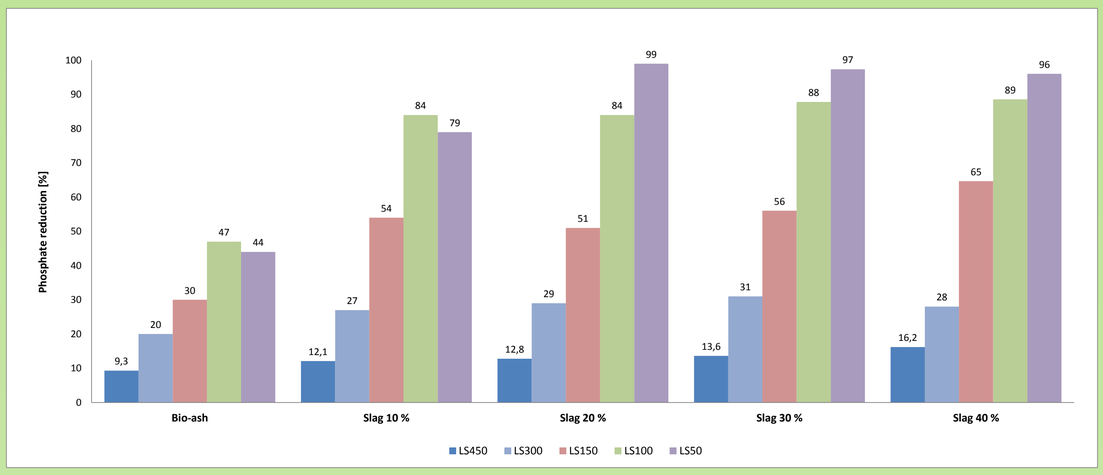

***Fig. 4.** Phosphate removal from 17.5 ppm aqueous solution by adsorption with symbiosis pellets.*

Publications

Karvonen, L., Pesonen, J., Kuokkanen, V., Kuokkanen, T. (2012) Tuhkien jakeistus, niiden kemialliset ominaisuudet ja hyödyntämispotentiaali. – tutkimusraportti EAKR-hankkeesta "Tuhkan rakeistus Pohjois-Pohjanmaalla, University of Oulu, Report Series in Chemistry, Report No. 86, 2012, 107 pp, available online: http://www.metla.fi/hanke/7464/pdf/tuhkan_rakeistus_p-pohjanmaalla_2012-07-20.pdf
Roininen, J., Kuokkanen, V. (2013) Using granulation (pelletizing) to increase the usage of slags - Proceedings of The 7th European Slag Conference, EUROSLAG, from 9th to 11th October, 2013, IJmuiden, The Netherlands, 13 pp.
Kuokkanen, T., Pöykiö, R., Nurmesniemi, H,. Rämö, J. (2011) Sequential Leaching of Heavy Metals and Sulphur in a Bottom and Fly Ash from Co-combustion of Wood and Peat at a Municipal District Heating Plant, *Chemical Speciation and Bioavailability* 18, 131-141.

Contact information

Ville Kuokkanen, D.Sc. (Tech) student, ville.kuokkanen@oulu.fi, 040-8401581

FACULTY OF SCIENCE
DEPARTMENT OF CHEMISTRY
APPLIED CHEMISTRY

HIGHBIO2 2011-2013
Biomass to Energy and Chemicals

CENTRE FOR ENVIRONMENT AND ENERGY

Gränslösa möjligheter
EUROPEISKA UNIONEN
Europeiska regionala utvecklingsfonden

INTERREG IV A NORD

UNIVERSITY of OULU
OULUN YLIOPISTO