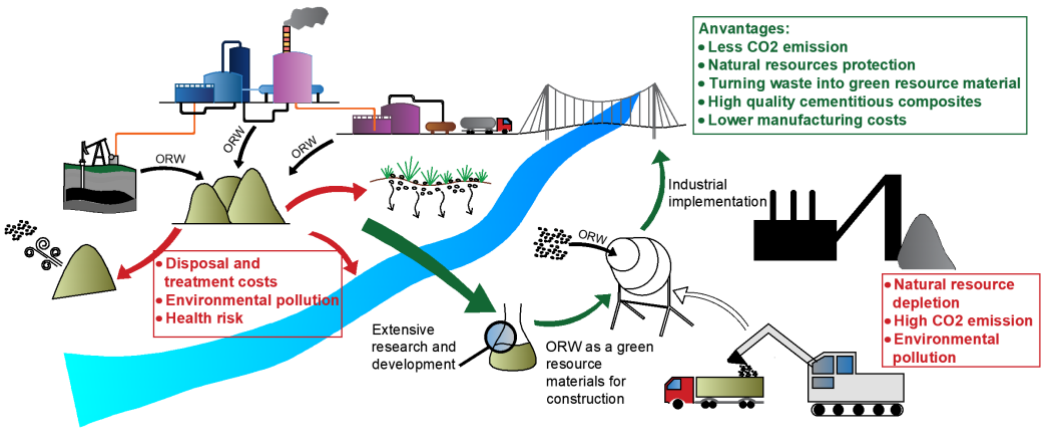
Experimental evaluation of influence of oil refinery waste materials used as a partial substitute of cement and natural aggregate on the properties of cement composite

The main aim of the project is a comprehensive research of the properties of cement composite incorporating oil refinery waste materials in different forms as a partial cement and natural aggregate substitute. Even though cementitious composites are the most important construction materials, manufacturing of their primary constituents, Ordinary Portland Cement (OPC) and natural aggregates, accounts for 5-8% of global CO_2 emission and consumes significant amounts of natural resources, thereby contributes to global environmental concerns. One of the approaches to cope with that challenge is to partially replace OPC and aggregates in cementitious composites with appropriate alternative materials possessing pozzolanic properties, often being industrial wastes, called Supplementary Cementitious Materials (SCMs). Within the scope of the proposed project, Oil Refinery Wastes (ORW), obtained from Polish oil-refinery, i.e.: spent Fluid Catalytic Cracking (FCC) catalyst, a mix of spent catalysts from Sulfure Recovery Unit (SRU), and Waste Ceramic Balls (WCB) as molecular sieve residues, have been selected to investigate their applicability as a novel SCMs in cement composites. These materials will be investigated not only in impurified forms, but also after chemical and thermal treatment, which might potentially allow to increase their reactivity and reduce toxicity. This research will enable to investigate scientific correlations between valorization of these materials and the impact of their recycling in cement composites on complete properties and toxicity of such composites and to understand mechanism of such ORW-cementitious systems. The motivation to conduct the research is the fact that such correlations are not known comprehensively in the literature, mentioning that SRU catalysts and WCB have not been previously tested. Additionally, spent catalysts containing heavy metals are withdrawn from single oil refinery in the annual amounts of 5515 tonnes and currently end their life-cycle in landfills, providing serious environmental and health risks. In this regard, the application of ORW in cementitious composites seems to be reliable course of action as it might potentially allow stable immobilization of contaminants in hardened composite's structure. Hence, the general idea of proposed project is graphically presented below.



The research plan includes three phases to be conducted: A - preliminary phase - consisting of purification of ORW adapting chemical oxidation and thermal calcination of contaminants and determination of their selected properties (direct pozzolanic activity, specific surface area, density, specific gravity, water absorptivity, porosity, etc.) to investigate the efficiency of purification and predict their potential impact on cement composites. Subsequently, the formulations of cement composites incorporating each ORW, in impurified and purified form, will be designed. B - main phase - consisting of tests performed on cement composites mixes and their cured samples to evaluate, respectively, their numerous fresh (consistency, density, air content) and hardened-state (flexural and compressive strength, frost resistance, water absorptivity, shrinkage, microstructure) properties as well as to determine the leaching of heavy metals (toxicity) from ORW and cement composite. C - final phase, where, based on the obtained results, the economical-environmental-mechanical analysis of composites will be carried out to demonstrate how the performances, CO_2 emission, natural resources consumption and cost related to the preparation of cement composite will change by the addition of each ORW. Also, the Life Cycle Assessment will be determined to demonstrate how the life-cycle of ORW regarding the leaching of heavy metals will change when incorporating these materials in cement composites instead of their landfilling. Accomplishment of the research plan will enable to discover the scientific correlations between various properties of ORW in purified and impurified forms and their complete impact on properties of cementitious composites and LCA of such composites with emphasis on their toxicity. Based on preliminary tests it might be targeted that substitution of up to 25% of cement or natural aggregate with ORW will enable preparation of cement composite with maintained or enhanced performances. The associated CO_2 emission, cost, and natural resources consumption will decrease for up to 25% while ORW will be converted into green-resource, solving the landfilling problem and prolonging their life-cycle.