According to the eco-philosophers, Klaus Michael Meyer-Abich and Albert Schweitzer, nature cannot be just a resource from that humans draw without any reflection. Both Meyer-Abich and Schweitzer believed that due to human beings abilities (creativity, conceptual thinking, cognitive, adaptive abilities) – only people can be responsible for his actions towards the environment, and only we, humans, are able to take activities aimed at protection of the environment. However, it requires empathy, reflection and an appreciation of the inner value of nature. By our actions, often rash, dictated by economic considerations, we lead to the degradation of the environment. Fortunately, human activities can restore balance to the environment. For this to happen, we need the commitment and hard work of all of us – appropriate theoretical preparation and practice, both in our homes and on an industrial scale.

One of the threats to the quality of the environment is the daily generated industrial waste, counted in hundreds of millions of tons. The amounts of side-streams are so large that the industry is not able to fully utilize this resource – the unused part most often ends up in landfills or fields (fertilizer). In recent years, more and more attention has been paid to sustainable development and the "zero waste" approach. The mentioned concept is to keep industrial residues in the economic cycle as long as possible. It should be remembered that industrial waste is a source of biologically active ingredients, such as: sugars, proteins, vitamins. Therefore, the possibility of recycling some of the by-products should be considered for the benefit of the environment and, in the long term, of the economy. An alternative to neutralizing side-streams is its use as a medium for microorganisms that would be able to produce essential and safe compounds from the nutritional sources contained in the waste (vitamin B12, propionic acid). The utilizing factor can be microorganisms that have been used in the food industry for years – lactic acid bacteria (LAB) and propionic acid bacteria (PAB). Vitamin B12 is unique among vitamins because it is synthesized exclusively by bacteria (including propionic bacteria), and its only source in the human diet is animal products. Taking into account the growing social awareness of concern for the environment and animal welfare, and thus the changing food trends (growing popularity of veg diets), it is likely that in the coming years there will be a fundamental shift in consumption patterns – from animal protein to vegetable protein. This is a huge challenge for the world of science, because regardless of the food source, the nutritional value of the consumed products must be maintained, and the most important nutrient that cannot be guaranteed by any plant in the diet is vitamin B12. Vitamin B12 deficiency leads, among others, to for neurological and hematological disorders. Another important metabolite of PAB is propionic acid (used as a preservative, e.g. in bread). The current production of this acid is based on petrochemical processes, which are quite cheap but harmful to the environment.

The main goal of the project will be optimization the production of vitamin B12 and propionic acid from edible plant side-streams as a result of the co-fermentation of LAB and PAB. We will also assess the possibility of safe fortification of vitamin B12 in the waste plant material. As part of the research, various industrial residues will be tested – apple pomace, strawberry pomace, grape pomace, blue honeysuckle berry pomace, banana peels, cereal bran. The mentioned side-streams will be checked for the content of nutritional sources and LAB and PAB metabolism stimulators (carbon and nitrogen sources, precursors of vitamin B12 and propionic acid synthesis). From the analyzed waste, for microbiological disposal will be selected those which are rich in compounds necessary for the development of lactic acid bacteria and propionic acid bacteria. In the next stage, LAB and PAB bacterial strains will be chosen, which will guarantee the efficient production of metabolites in the waste matrices. Then, we will optimize the production of vitamin B12 and propionic acid from side-streams as a result of LAB and PAB co-fermentation (waste medium development, selection of fermentation conditions). The final stage will be an attempt to safely fortify vitamin B12 in a waste medium optimized for the synthesis of vitamin B12. We assume that co-fermentation of two different groups of bacteria can help to improve the process of waste disposal and intensify the production of metabolites. LAB and PAB co-fermentation is successfully used in cheese industry. LAB prepare the environment for propionic acid bacteria – e.g. by producing lactic acid, which is a preferential nutrient source for PAB. Moreover, vitamin B12 obtained with the use of LAB and PAB strains and plant residues would have great application properties, as it would be a fully vegan and natural product. Co-fermentation of LAB and PAB may be a solution improving the taste and safety of the waste matrix – due to the production of various antimicrobial compounds (lactic acid, bacteriocins). The production of vitamin B12 and propionic acid during LAB-PAB co-fermentation in matrices containing several different waste materials has not been described so far. The research planned in the grant is interdisciplinary – it includes research in the field of environmental protection (waste management), microbiology (fermentation, co-fermentation), safe food design (fortification of vitamin B12, analysis of the product for safety) and physiology (bioaccessibility of fortified vitamin B12).