Sustainability of agricultural practices in Germany: a literature review along multiple environmental domains

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Supplementary Material 2: Indicator Definitions and Positive Direction of Relationship

* CLIMATE

Above ground carbon sequestration: Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change (USGS, 2020). Positive (+) values are associated with a higher rate of above ground carbon sequestration.

Air Pollution: Within this excel sheet, air pollution is associated with an increase in NH3. Negative (-) values are associated with less air pollution.

Albedo: Albedo is the proportion of the incident light or radiation that is reflected by the surface (Goward, 2005). Positive (+) values are associated with a higher reflection of sunlight and therefore with a cooling effect.

Carbon storage in biomass: Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change (USGS, 2020). Positive (+) values are associated with a higher rate of carbon storage in biomass.

CH4: Methane emissions. Negative (-) values are associated with less greenhouse gas emissions.

Climate Regulation: Positive (+) values are associated with a higher regulation of climate.

CO2: Carbon dioxide emissions. Negative (-) values are associated with less greenhouse gas emissions.

GHG emissions: Greenhouse gas emissions include carbon dioxide, water vapor, methane, ozone, nitrous oxide and fluorinated gases (Mann, 2019). Negative (-) values are associated with less greenhouse gas emissions.

Global warming potential: GWP is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (EPA, 2020). Negative (-) values are associated with a lower global warming potential.

Greenhouse gas intensity: GGI is a ratio comparing the greenhouse gas emissions of an activity or economic sector the economic value it generates. Negative (-) values are associated with a lower ratio.

N2O: Nitrous oxide emissions. Negative (-) values are associated with less greenhouse gas emissions.

NH3: Ammonia emissions. Negative (-) values are associated with less climate sensitive gas emissions.

Pastoral greenhouse gas emissions: Greenhouse gas emissions from the agricultural sector. Negative (-) values are associated with less greenhouse gas emissions.

Resilience: Climate resilience. Ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate (C2ES, 2020). Positive (+) values are associated with a higher resilience towards climate change.

Risk management: Positive (+) values are associated with a beneficial risk management interlinked with global warming.

Temperature: Negative (-) values are associated with a lower temperature, which is especially beneficial in high temperature regions & during hot seasons.

** SOIL

(Macro) Porosity: Soil porosity is the gap between solid particles, which contain water and air (Zhang et al., 2019). Positive (+) values are associated with a higher number of gaps and therefore better water/ air storage.

(Total) nitrogen: Amount of nitrogen in the soil, including inorganic and organic forms. Positive (+) values mean that less inorganic nitrogen may be required for cash crops.

(Total) Phosphorous/P: Amount of total phosphorous in the soil. Positive (+) values mean that less (inorganic) fertilizer may be required for cash crops.

Aggregate stability: Ability of soil aggregates to hold together during disturbances such as rain. Positive (+) values indicate greater stability and more resistance to erosion and crusting.

AWHC: Available water holding capacity. Positive (+) values are associated with a higher amount of water available to roots and plants.

Beta-glucosidase: Beta-glucosidase is an enzyme that decomposes organic matter into soil. Positive (+) values indicate a higher number of these enzymes within a soil.

BS: Refers to base saturation, which indicates the balance between acid and base cations adsorbed by CEC in a soil. Positive (+) values indicate a higher BS.

Bulk density: Mass of soil particles within a given volume. Negative (-) values are associated with more pore space and less compaction.

C mineral content: Amount of carbon mineral content within a soil. Positive (+) values mean that less fertilizer may be required for cash crops.

C:N ratio: A carbon-to-nitrogen soil ratio is a ratio of the mass of carbon to the mass of nitrogen within the soil. A higher C:N ratio is beneficial, although it must not be too high. Positive (+) values indicate a higher ratio.

Carbon sequestration: Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change (USGS, 2020). Positive (+) values are associated with a higher rate of soil carbon sequestration.

CEC: Refers to the cation exchange capacity which is an indicator that a soil has a high SOM and/or clay content and can hold many cations. Positive (+) values indicate a high CEC.

Dehydrogenase activity: Dehydrogenases play a significant role in the biological oxidation of soil organic matter (Zhang et al., 2010). Positive (+) values are associated with a higher dehydrogenase activity.

EC: Refers to electricity conductivity and a measure of the amounts of salts within a soil. Positive (+) values indicate a higher EC.

Enzyme: Refer to enzymatic assays which measure soil enzyme activity. Positive (+) values are associated with a higher enzyme activity.

Erosion: Movement and/or loss of soil due to wind or rain. Negative (-) values mean that less soil is affected by erosion.

Fungal/ Formation of arbuscular mycorrhizas fungi: Refer to soil-borne fungi that can significantly improve plant nutrient uptake and resistance to stress. Positive (+) values indicate a higher number of arbuscular mycorrhizas fungi.

Heavy metal availability: Soils containing heavy metals (possessing biological toxicity) are considered as contaminated. Negative (-) values indicate a lower heavy metal availability within a soil.

Infiltration rate: Rate at which water can enter into the soil. Positive (+) values indicate that soil will absorb more water and have less overland flow during rain.

K (availability): Total potassium content in the soil, it serves as a regulator of metabolic activities. Positive (+) values mean that less (inorganic) fertilizer may be required for cash crops.

KS: Saturated hydraulic conductivity, which controls the rate of water movement through soil. Positive (+) values indicate that water will move with less resistance into and through soil.

Land sharing & sparing: Refers to a sustainable intensification that is necessary to feed the growing number of people with limited environmental impacts. Positive (+) values indicate a maximisation of land sparing and sharing.

Metal adsorption: Adsorption of metal within a soil. Positive (+) indicate a higher adsorption of metal.

Microbial activity: Soil microbial activity that reflects microbiological processes of soil microorganisms is the potential indicator of soil quality, as plants rely on soil microorganisms to mineralize organic nutrients for growth and development (Chen et al., 2003). Positive (+) values are associated with a higher microbial activity.

Microbial biomass C: Carbon associated with soil microbes. Positive (+) values are associated with beneficial biological functions and more plant available carbon.

Microbial biomass N: Nitrogen associated with soil microbes. Positive (+) values are associated with beneficial biological functions and more plant available nitrogen.

Microbial biomass: Microbial biomass (bacteria and fungi) is a measure of the mass of the living component of soil organic matter (Soil quality, 2020). Positive (+) values are associated with beneficial biological functions and more plant available nutrients.

Microbial quotient: Microbial quotient is the ratio of microbial biomass to soil organic carbon and indicates how efficiently soil organic matter is being used by microorganisms (Pankurst, 2002). Positive (+) values indicate a higher microbial quotient.

N mineral content: Amount of nitrogen mineral content within a soil. Positive (+) values mean that less fertilizer may be required for cash crops.

N recovery: Nitrogen plant recovery. Positive (+) values are associated with a higher plant N recovery.

Nitrate concentration: Amount of nitrate in the soil. Positive (+) values mean that less nitrate may be required for cash crops.

N-supply potential: Amount of potential nitrogen supply in the soil, including inorganic and organic forms. Positive (+) values mean that less inorganic nitrogen may be required for cash crops.

Nutrient availability/efficiency: Available source/efficiency of nutrients for plant growth. Positive (+) values are associated with a higher availability or efficiency of nutrients.

Nutrient retention: Positive (+) values indicate a higher retention of nutrients.

Nutrients available including N fixation: Available source of nutrients for plant growth & nitrogen fixation refers to the conversion of atmospheric N into a combined form, it is essential to life as the compounds are required for biosynthesis. Positive (+) values are associated with a higher availability of nutrients.

O-Microbial: Refers to other microbial indicators. Positive (+) values are associated with higher microbial indicators.

Oxygen in flooded environments: Flooded soils are rapidly depleted of oxygen which has severe effects on soil organisms and plants. Positive (+) values indicate a higher level of oxygen in flooded soils.

P (availability): Total phosphorous content in the soil. Positive (+) values mean that less (inorganic) fertilizer may be required for cash crops.

Penetration: Penetration resistance. Positive (+) values mean a higher resistance towards penetration.

pH: Refers to the acidity or basicity of a soil. Positive (+) values are associated with a less acid soil, although a very alkaline soil is also not beneficial for the soil.

Plant ground cover: Here; a higher plant ground cover may lead to less erosion and runoff & a lower bulk density. Positive (+) values are associated with more plants covering the soil.

Redox potential: The redox potential is a main driver of soil, plant & microorganisms systems. A positive redox potential indicates the ability to accept electrons, the negative one to donate electrons (Husson, 2013). Positive (+) values are associated with a higher redox potential.

Runoff: Water that ponds up on the soil surface and moves as overland flow. Negative (-) values means less overland flow, meaning less erosion and greater replenishment of soil water.

SIR: Refers to the substrate-induced respiration and is used to determine the microbial biomass within a soil. Positive (+) values are associated with a higher microbial biomass.

Soil (macro)fauna (population): The soil macrofauna have been described as 'facilitators' or 'regulators' of interactions between other groups of organisms, and this may well be one of their most important roles in ecosystem function (Winsome, 2005). Positive (+) values indicate a higher population of soil macrofauna.

Soil acidification: Acidification can make the soil too acid for growing land plants. Negative (-) values indicate a de-acidification of soils.

Soil biodiversity: Refers to the variety of life belowground. Positive (+) values are beneficial for the soil and associated with a higher number of soil microorganisms, small animals, etc. within the soil.

Soil compaction: Refers to the process in which stress is applied to a soil and causes densification as the air within the soil is displaced. Negative (-) values are associated with more pore space and less compaction.

Soil desalinization: Salinization refers to a build-up of salt within the soil, this can make the soil too salty for growing land plants. Positive (+) values indicate a desalinization of soil.

Soil friability*:* Friable soil is soil that has the crumbly texture ideal for the underground activity that is the foundation of success with most plants (DCA, 2013). Positive (+) values indicate more friability of the soil.

Soil organic carbon: Organic matter associated carbon in soil. Positive (+) values are associated with greater soil water holding capacity and better structure.

Soil organic matter: Soil organic matter (SOM) has a strong correlation to soil fertility and high affection to crop production and consists of plant and animal detritus, cells and tissues as well as other substances of soil microbes. Positive (+) values are associated with a higher level of SOM.

Soil organisms: Soil organisms, which range in size from microscopic cells that digest decaying organic material to small mammals that live primarily on other soil organisms, play an important role in maintaining fertility, structure, drainage, and aeration of soil (EB, 2016). Positive (+) values indicate more soil organisms and a healthier soil.

Soil quality/ health/ structure/ fertility: Here; soil physics & fertility & biology. Positive (+) values are associated with beneficial functions of the soil.

Soil stabilization: Soil stabilization refers to biological and physical processes which increase or maintain the stability of a soil (Espeland et al., 2018). Positive (+) values indicate a higher stability of soil.

Specific compound degradation: Here; degradation of e.g. organic pollutants. Positive (+) values indicate a higher compound degradation.

ST: Soil temperature. Negative (-) values mean a lower temperature on average and less GHG fluxes.

SWC: Soil water content. Positive (+) values mean a higher amount of water (volume or mass) contained in a unit volume or mass of soil.

Water retention: Water retention in soil can be understood as the water retained by the soil after it runs through the soil pores to join water bodies such as groundwater or surface streams (GY, 2018). Positive (+) values are associated with a higher level of water retention.

Weed abundance: Biomass associated with weeds during the cash crop growing season. Negative (-) values mean that fewer weeds were found in the field after introducing the TB, therefore development of less competitive and easy manageable weed communities.

*** WATER

(Microbial) water quality: Water quality is used to describe the condition of the water, including its chemical, physical and biological characteristics, usually with respect to its suitability for a particular purpose (Diersing, 2009). Positive (+) values are associated with a higher water quality.

(Nutrient) leaching/runoff: Water that drains below the root zone. Negative (-) values mean less leaching, which can reduce loss of fertilizers and herbicides/pesticides from soil.

(Total) Nitrogen leaching/ runoff/ loss: Occurs when nitrogen leaves the soil in drainage water and below the root zone. Once nitrogen gets into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower leaching/ runoff/ loss rate.

(Total) Phosphorous leaching/ loss: Occurs when phosphorous leaves the soil in drainage water and below the root zone. Once phosphorous gets into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower leaching/ loss rate.

Ammonium-N leaching: Occurs when ammonium-N leaves the soil in drainage water and below the root zone. Once ammonium-N gets into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower leaching rate.

Antibiotics usage: A high water quality requires that the antibiotics used do not contaminate water sources. A lower usage of antibiotics can support a higher water quality. Negative (-) values are associated with less sediments being used.

Blue carbon value: Blue carbon refers to carbon dioxide removed from the atmosphere by the world's coastal ocean ecosystems, through plant growth and the accumulation and burial of organic matter in the soil (Nellemann et al., 2009). Positive (+) values are associated with a higher value of blue carbon.

Coastal protection: Positive (+) values indicate a higher level of coastal protection.

Contamination of downstream water sources: Negative (-) values are associated with less contamination of downstream waterbodies.

Dissolved inorganic N leaching: Occurs when dissolved inorganic nitrogen leaves the soil in drainage water and below the root zone. Once dissolved inorganic N gets into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower leaching rate.

Dissolved N loss/ runoff: Occurs when dissolved nitrogen leaves the soil in drainage water and below the root zone. Once dissolved nitrogen gets into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower loss/ runoff rate.

Dissolved P loss/ runoff: Occurs when dissolved P leaves the soil in drainage water and below the root zone. Once dissolved P gets into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower loss/ runoff rate.

Dissolved reactive P loss: Occurs when dissolved reactive P leaves the soil in drainage water and below the root zone. Once it gets into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower loss rate.

Fertilizer usage: A high water quality requires that the fertilizers used do not contaminate water sources. A lower usage of fertilizer can support a higher water quality. Negative (-) values are associated with less fertilizer being used.

Fertilizer use efficiency: An efficient relationship between the economically optimum nourishment to the crop while minimizing fertilizer losses from the field. Positive (+) values indicate a higher efficacy of fertilizer usage.

Flood risk: Negative (-) values indicate a lower risk of floods.

Groundwater nitrogen: If nitrogen gets into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower groundwater nitrogen rate.

Hydraulic lift by nurse plants: Hydraulic lift is a process by which plants take up water from deep, moist soil layers and passively transport and release it into shallow, drier soil layers (Caldwell et al., 1998). Positive (+) values are associated with a higher rate of hydraulic lift.

Hydrological balance: The hydrological balance can be used to describe the flow of water in and out of a system. Positive (+) values indicate a more balanced hydrological system.

Input of sediments: A high water quality requires that the sediments used do not contaminate water sources. A lower input of sediments into the soil can support a higher water quality. Negative (-) values are associated with less sediments being used.

Nitrate leaching/loss/runoff: Occurs when nitrogen leaves the soil in drainage water and below the root zone. Once nitrogen gets into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower leaching/ loss/ runoff rate.

Nitrogen & Nitrate removal: If nitrogen & nitrate are being removed, they may not enter water bodies and therefore serve as an environmental pollutant. Positive (+) values indicate higher rates of removal.

Nitrogen use efficiency: An efficient relationship between the economically optimum nourishment to the crop while minimizing nutrient losses from the field. Positive (+) values indicate a higher efficacy of nitrogen usage.

Nitrogen use: Negative (-) values indicate a lower usage of nitrogen which could reach e.g. waterbodies by e.g. runoff, leaching or erosion.

Particulate N loss/ runoff: Occurs when particulate nitrogen leaves the soil in drainage water and below the root zone. Once particulate nitrogen gets into the ground water and other fresh water

bodies it is an environmental pollutant. Negative (-) values are associated with a lower loss/ runoff rate.

Particulate P loss/ runoff: Occurs when particulate phosphorous leaves the soil in drainage water and below the root zone. Once particulate phosphorous gets into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower loss/ runoff rate.

Pesticide & herbicide usage: A high water quality requires herbicides and pesticides used do not contaminate water sources. A lower usage of pesticides and herbicides can support a higher water quality. Negative (-) values are associated with less pesticide and herbicide being used.

Pesticide leaching/ runoff/ loss: Occurs when pesticides leave the soil in drainage water and below the root zone. Once pesticides get into the ground water and other fresh water bodies they are an environmental pollutant. Negative (-) values are associated with a lower leaching/ runoff/ loss rate.

Pesticide removal: If pesticides are being removed, they may not enter water bodies and therefore serve as an environmental pollutant. Positive (+) values indicate higher rates of removal.

PP concentration in surface runoff: PP refers to both particulate forms of phosphorous. A lower concentration in surface runoff means a lower concentration in proximate waterbodies, thus negative (-) values are better for the environment.

Relative humidity: Positive (+) values indicate a higher level of humidity.

Spray drift of pesticide: Pesticide spray drift is the movement of pesticide dust or droplets through the air at the time of application or soon after, to any site other than the area intended, e.g. water bodies (EPA, 2020b). Negative (-) values are associated with a lower movement of pesticide dust or droplets into water bodies.

Suspended sediments: Occurs when sediments leave the soil in drainage water and below the root zone. Once they get into the ground water and other fresh water bodies it is an environmental pollutant. Negative (-) values are associated with a lower loss rate.

Water eutrophication: Eutrophication is when a body of water becomes overly enriched with minerals and nutrients which induce excessive growth of algae (Chislock et al., 2013). Negative (-) values are associated with less water eutrophication.

Water flow regulation: Water flow regulation refers to buffering and attenuation of mass flows, hydrological cycle and water flow maintenance. Positive (+) values are associated with a higher water flow regulation.

Water logging: Waterlogging occurs when there is too much water in a plant's root zone, which decreases the oxygen available to roots. Waterlogging can be a major constraint to plant growth and production and, under certain conditions, will cause plant death (DPIRD, 2020). Negative (-) values are associated with less water logging.

Water purification: Positive (+) values indicate cleaner and healthier water.

Water regulation: Water sediment, nutrient and bacteria. Positive (+) values mean a better water quality.

Water usage: Water use describes the total amount of water withdrawn from its source to be used. Negative (-) values are associated with less water to be used.

**** BIODIVERSITY

Biodiversity loss: Negative (-) values are associated with a lower level of biodiversity loss.

Biodiversity: Biodiversity is the variety and variability of life on Earth. Positive (+) values mean a higher level of biodiversity expressed as e.g. abundance, richness, habitat & composition.

***** COSTS

Animal production per hectare: Positive (+) values are associated with a higher stocking rate per hectare.

Animal weight gain: Positive (+) values indicate a higher level of weight gain of livestock.

Biomass production: Biomass is plant or animal material used for e.g. energy production (electricity or heat). Positive (+) values are associated with a higher production of biomass.

Biomass provision & energy yield: Positive (+) values are associated with a higher level of biomass and energy yield.

Cash crop biomass: Cash Crop Biomass production, positive (+) values mean that on average crop biomass production will improve.

Cash crop yield: Cash crop yield for the season following winter cover crops. Positive (+) values mean that on average the cash crop will have a higher yield.

Crop damage from slugs: Negative (-) values are associated with a lower loss of cash crops because of less damage from slugs.

Disease incidence: Negative (-) values are associated with lower disease incidences.

Livestock losses: Negative (-) values indicate a lower rate of livestock losses due to e.g. pests or diseases.

Livestock productivity: Positive (+) values indicate a higher productivity per livestock.

Pest control: Positive (+) values are associated with a beneficial pest control.

Tillage energy requirement: Negative (-) values are associated with less energy requirement during tillage.

******SOURCES

C2ES – Center for climate and energy solutions (2020). Climate Resilience Portal, https://www.c2es.org/content/climate-resilience-overview/, [17.07.2020].

Caldwell, M.; Dawson, T.; Richards, J. (1998). Hydraulic Lift: Consequences of Water Efflux from the Roots of Plants, in: Oecologia, 113(2), pp. 151 – 161.

Chen, G.; Zhu, H.; Zhang, Y. (2003). Soil microbial activities and carbon and nitrogen fixation, in: res Microbiol., 154(6), pp. 393 – 398.

Chislock, M. F.; Doster, E.; Zitomer, R. A.; Wilson, A. E. (2013) Eutrophication: Causes, Consequences, and Controls in Aquatic Ecosystems, in: Nature Education Knowledge, 4(4):10.

DCA – Danish Centre for Food and Agriculture (2013). Soil friability is the key, https://dca.au.dk/en/tempside/show/artikel/soil-friability-is-the-key/, [17.07.2020].

Diersing, N. (2009). "Water Quality: Frequently Asked Questions." Florida Brooks National Marine Sanctuary, Key West, FL.

DPIRD – Department of Primary Industries and Regional Development (2020). Agriculture and Food – Waterlogging, https://www.agric.wa.gov.au/climate-land-water/soils/managing-soils/waterlogging, [17.07.2020].

EB – Encyclopaedia Britannica (2016). Soil Organism, https://www.britannica.com/science/soil-organism, [27.07.2020].

EPA - United States Environmental Protection Agency (2020b). Introduction to Pesticide Drift, https://www.epa.gov/reducing-pesticide-drift/introduction-pesticide-drift, [17.07.2020].

EPA – United States Environmental Protection Agency (2020a). Understanding Global Warming Potentials, https://www.epa.gov/ghgemissions/understanding-global-warming-potentials, [17.07.2020].

Goward S.N. (2005) Albedo and Reflectivity. In: Oliver J.E. (eds) Encyclopedia of World Climatology. Encyclopedia of Earth Sciences Series. Springer, Dordrecht . https://doi.org/10.1007/1-4020-3266-8_8.

GY – Geography and You (2018). Water retention in soils: Characteristics and treatment, https://geographyandyou.com/water-retention-soil/, [17.07.2020].

Husson, O. (2013). Redox potential (Eh) and pH as drivers of soil/plant/microorganism systems: A transciplinary overview pointing to integrative opportunities for agronomy, in: Plant and Soil, 362, pp. 389 – 417.

Mann, M. (2019). Encyclopaedia Britannica – Greenhouse Gas, https://www.britannica.com/science/greenhouse-gas, [17.07.2020].

Nellemann, C.; Corcoran, E.; Duarte, C.; Valdes, L. (2009): Blue Carbon. The Role of Healthy Oceans in Binding Carbon. A Rapid Response Assessment. Arendal, Norway: UNEP/GRID-Arendal.

Pankhurst CE, Kirkby CA, Hawke BG and Harch BD (2002) 'Impact of change in tillage and crop residue management practice on soil chemical and microbiological properties in a cereal-producing red duplex soil in NSW, Australia', *Biological Fertility of Soils* **35**:189-196.

Soil Quality (2020). Microbial Biomass, http://soilquality.org.au/factsheets/microbial-biomass, [17.07.2020].

USGS – Science for a changing world (2020). What is carbon sequestration?, https://www.usgs.gov/faqs/what-carbon-sequestration?qt-news_science_products=0#qt-news_science_products, [17.07.2020].

Winsome, T. (2005). FAUNA - Participation in Belowground and Aboveground Food Webs, in: Encyclopedia of Soils in the Environment, pp. 539 – 548.

Zhang, N.; He, X.; Gao, Y.; Li, Y.; Wang, H.; Zhang, R.; Yang, S. (2010). Pedogenic Carbonate and Soil Dehydrogenase Activity in Response to Soil Organic Matter in Artemisia ordosica Community, in: Pedosphere, 20(2), pp. 229 – 235.

Zhang, S.; Zhu, X.; Zhou, S.; Shang, H.; Luo, J,M Tsang, D.C.W. (2019). Hydrothermal Carbonization for Hydrochar Production and Its Application, in: Ok, Y.S.; Tsang, D.C.W.; Bolan, N.; Nivak, J.M (Edts.) Biochar from Biomass and Waste, pp. 275 – 294.