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A HOLISTIC APPROACH TO PREDICT, MEASURE AND REDUCE ENVIRONMENTAL PRESSURES OF POLYMETALLIC NODULE COLLECTION

R.L.J. Helmons[1,2]

There is an expected increase in demand of critical raw materials, e.g. nickel and cobalt, mainly driven by the shift towards renewable energy solutions and the increase in production of electric vehicles. That trend has raised the interests for the mining of polymetallic nodules. The most extensive nodule depostions are found on the abyssal plains of the deep seas. In spite of their economic interest, concerns have been raised regarding the environmental impact of deep sea mining.

Of major concern are sediment plumes that will be generated by the mining activities. Such turbidity flows might impact the environment through sediment dispersion and bottom blanketing within the vicinity of the mining site could potentially bury benthic organisms, clog the respiratory surfaces of filter feeders and pollute the food supply for most benthic organisms. How far these plumes can reach and how severely they affect the deep-sea ecosystem is presently unknown (Washburn, et al., 2019). Given these uncertainties, from a technical point of view, it is of importance to 1) be able to accurately predict where these plumes will travel and what deposition layer will be generated and 2) identifying under what conditions dispersion of said plumes will be minimal.

Most of the nodule collector systems designs are targeted for a high nodule pickup efficacy and capacity. However, this is only part of the collectors performance, the sediment release conditions should also be included. Optimization of the release conditions of these sediments is expected to allow for a significant reduction of the spread of the turbidity flows. It is in the so-called near-field (<few hundreds of meters), relative to the mining vehicle, where engineering solutions might be able to influence the development and thus spread of the sediment plumes. It is expected that all sediment deposition that can be achieved in this near-field region, will help to reduce the environmental pressure generated by the plumes further away.

At Delft University of Technology, this philosophy culminates in several research projects, that combined allows us to use a holistic approach to aim to predict and reduce the sediment plume dispersion. So far, most of the designs start from an economical point of view, i.e. achieving an effective nodule pick-up. However, in our approach, we start by identifying under what conditions the dispersion of the discharged plume are expected to be reduced.

Typically, the sediments of the abyssal plains consists of very fine sediments, with a d_{50} of 20 micron (Gillard, et al., 2019) and thus a low settling velocity. As a result, low concentrations of suspended sediment are expected to travel up to a few kilometres beyond the mining activity. As the sediments mainly consist of clay, particle aggregation can be an advantageous effect to increase the settling velocity of the particles and thus potentially reduce suspended sediment concentration. This will effectively lower the driving force of turbidity currents and as a result, the sediment dispersion can be reduced. Various observations indicate that a higher concentration is likely to result in more significant particle aggregation and non-Newtonian behaviour of the mixture.

In the Blue Harvesting project, together with industry and European universities and research institutes, a new design of a hydraulic collector is developed. This design is based on reduction of the water intake in order to increase the sediment concentration in the discharged flow. The system has already been tested in the laboratory, first on a scale of 1:2, followed by full scale. Later in 2022 it will be tested in the field as well.

In the PLUMEFLOC project, it is investigated how particle aggregation influences the dispersion of low-density turbidity flows. This is done through analysis of the micro-mechanics of the aggregation process and assessing its sensitivity to sediment concentration, mixing and the presence of a flocculant. Based on this knowledge, it is studied how the aggregation process will be influencing the hydrodynamics of turbidity flows and vice versa. This is investigated through various lock exchange and diffuser outflow experiments. Together with NIOZ, it is studied how to appropriately measure and asses the aggregation process on field scale.

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Finally, based on the experience gained in these deep-sea mining related projects and our experience in conventional dredging processes lead us to participate in a new consortium that determines the requirements to adequately monitor the environmental conditions during and after deep sea mining exploitation. Within the project, a monitoring system will be designed, built and tested up to TRL3-5. By the time of WODCON, the proposal will have been submitted to EU's Horizon program.

Key words: Deep-sea mining; flocculation; monitoring; hydraulic excavation, sediment dispersion

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