Chapter

Impact of Salt on Cohesive Sediment Transport

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Abstract

The erosion and transport of cohesive sediment are more difficult to study than non-cohesive sediment, largely because these processes vary with the salt in the water. Clay minerals are the major components that contribute to the cohesiveness of cohesive sediment because they have significantly larger surface charges and surface area-to-volume ratio than non-cohesive sediment. The electrochemically active clay surfaces can adsorb ions on their surfaces, form an electrical double layer, and cause clay particles to aggregate or form a gel. In this chapter, we first discuss the properties of clay minerals, including the structure of clay primary particles, their surface charge and area, and their interaction with ions in water. The surface charges and surface areas of clay are several orders of magnitude larger than non-cohesive sand, thus predisposing it to interactions with salt in aqueous environments. Second, we summarize studies that reveal the role of salts, specifically salinity and sodium absorption ratio (SAR), on sediment aggregation, stability, and settling speed. An increase in salinity from 0.15 to 1.5 ppt has been shown to increase the erosion threshold of smectite clay by more than 10 times. These findings underscore the crucial role of salt in shaping cohesive sediment transport.

Keywords: cohesive sediment, clay, mud, transport, salinity, ions, salt, sodium adsorption ratio

1. Introduction

A fundamental understanding of sediment transport and the effects of salts is essential for managing water resources, protecting habitats, and addressing concerns. Clay minerals, widely present in cohesive sediment, can interact with salts and sediment movement. In the following section, we summarize the characteristics of clay minerals including their classification, particle size distribution, surface area, and surface charges. These characteristics dictate how clay particles aggregate and interact with ions in water. We then explore the formation and significance of the electrical double layer (EDL) surrounding clay particles. We discuss the role of EDL in particle aggregation, dispersion, and transport. In the third section, we delve into studies that investigate how salinity influences sediment transport processes. We analyze how variations in salt concentrations affect factors like coagulation processes, stability levels of sediments, particle size distributions, and settling rates of clay aggregates. In Section 4, we examine the effects of sodium adsorption ratio (SAR) and sodicity on erodibility to underscore their significance in soil erosion processes across soil types. In Section 5, we delve into research elucidating the correlation between salt content and the gelatinous status of smectite clay, providing insight into the influence of salt quantity on clay erosion thresholds. Finally, we present viewpoints on how salt interacts with clay minerals and impacts sediment transport in aquatic environments.

2. Clay minerals

2.1 The properties and classifications of clay minerals

Cohesive sediment is ubiquitous in aquatic ecosystems, and clay is a major component of cohesive sediment [1]. In many fields such as geomorphology, clay is defined as fine sediment particles less than 2 microns [2]. Many of these micron-size clay particles, obtained by sieving the soils and sediment collected from the field, are made up of thousands to millions of nanometer-size clay primary particles, which are aluminosilicates that have layered structures. Clay minerals are a major contributor to the cohesiveness of sediment aggregates due to their large surface-area-to-volume ratio and large surface charges. Many clay minerals, such as kaolinite and smectite, consist of SiO_4 tetrahedral and AlO_4 octahedral structures, and they can be classified into two types based on how the tetrahedral and octahedral sheets are arranged, as shown in **Figure 1**. The first type is called the 1:1-layer type or silicate clay, which consists of one tetrahedral sheet bonded to one octahedral sheet through hydrogen bonds. This type of clay has a typical particle size of less than 10 μm, and a surface charge ranging from 0.5 to 9×10^4 m^2 kg^{-1}. An example of this type is kaolinite. The second type is known as the 2:1 layer type or smectite clay and it includes one octahedral sheet positioned between two tetrahedral sheets. Both illite and smectite clay have a 2:1 layer structure. The mean thickness of the smectite primary particle is on the order of 1 nm [3]. The structure of montmorillonite, a common smectite clay, is shown in **Figure 1**. The total surface area of smectite is about 700 m^2 g^{-1}.

In general, clay minerals can be further classified into five groups based on cation substitutions occurring within their layers. These groups include kaolinite (chemical composition: $Al_2Si_2O_5(OH)_4$), illite ($M_x[Si_{6.8}Al_{1.2}]$ $Al_3Fe_{0.25}Mg_{0.75}O_{20}(OH)_4$), vermiculite $M_x[Si_7Al]$ $Al_3Fe_{0.5}Mg_{0.5}O_{20}(OH)_4$, smectite ($M_x[Si_8]Al_{3.2}Fe_{0.2}Mg_{0.6}O_{20}(OH)_4$),

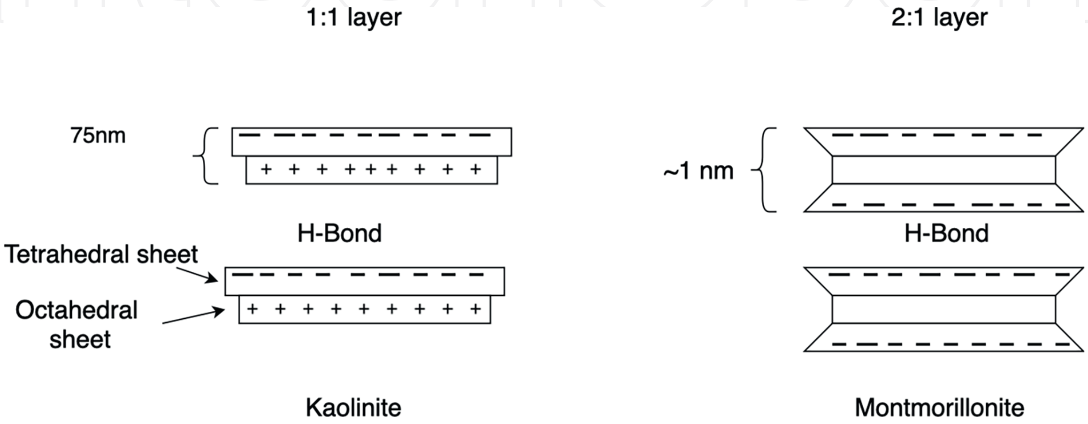

Figure 1.
Schematic diagrams of kaolinite and montmorillonite, which represent 1:1 and 2:1 clay types. Their sizes are indicated in the figure.

and chlorite ($(Al(OH)_{2.55})_4$ $[Si_{6.8}Al_{1.2}]$ $Al_{3.4}Mg_{0.6}O_{20}(OH)$). Each group has different characteristics and plays an important role in geological and environmental processes [4]. In this article, we focus on discussing kaolinite and smectite because they are the two most common clay and represent the 1:1 and 2:1 clay types.

2.2 The size distribution of clay primary particles

Most of the clay minerals are nano- to micro-size particles. For example, the lengths of kaolinite particles have three peaks, located at 0.075, 0.3, and 1.2 μm [5]. The smallest peak, which makes up 10–15% of the particles may indicate the thickness of kaolinite particles. The other two peaks correspond to the dimensions of the kaolinite's basal plane resulting in aspect ratios of 16 and 4, respectively [5]. The other two dimensions of smectite clay have been shown to range from 100 to 200 nm [4]. Ca^{2+} montmorillonite, a typical smectite clay, demonstrates two particle sizes reaching their peak at 0.6 and 1.5 μm while Na^+ montmorillonite shows a single prominent particle size with the highest occurrence, at 1.5 μm. These distributions provide information about the size features of montmorillonite [5].

2.3 Surface area and charges

Clay aggregates have extensive internal surface area because they consist of layers of clay primary particles. These layers of some clays such as kaolinite and montmorillonite are structured like a book, leading to significantly more internal surface area. For example, the surface area of kaolinite ranges from 169 to 170 m^2/g [6], which is about three orders of magnitude larger than the surface area of non-cohesive sand of a similar weight.

The surfaces of many clay minerals are mostly electronegatively charged. However, this might change depending on the chemical composition and pH of the surrounding solution. Specifically, the clay surface attracts thousands of cations like Na^+, H^+, and Ca^{2+}, which induces an ionic double-layer [7]. The electric charge, on pristine kaolinite clay nanoparticles measured through electrostatic force microscopy (EFM) is around 25 nC/cm^2 [8]. Estimation of the surface charge of clay is difficult because the clay can exchange cations with the solution and change its surface charge. For example, the surface charges of kaolinite are pH-dependent—its surface charge ranges from 2.9×10^{-14} to 6.4×10^{-15} nC/cm^2 for pH between 4 and 6 and becomes negative (-4.5×10^{-14} nC/cm^2) at pH = 9 [9]. Due to these large surface charges, clay can adsorb abundant cations on their surfaces and exchange abundant cations with the surrounding solution. The interactions between clay and cations are linked with the cation exchange capacity (CEC) of soils.

The interactions between clay and cations also depend on the type of cations because the interactions between clay minerals and multivalent cations are different from their interactions with monovalent cations. Multivalent cations can bridge two negatively surfaces charged surfaces. For example, a calcium cation with two positive charges can bind to a negatively charged clay particle on one side and capture another negatively charged clay particle on the other side, causing these clay particles to aggregate [10]. Bridging clay particles is a key mechanism behind the flocculation phenomenon [11]. Clay's retention and aggregation have been consistently shown to increase in the presence of divalent or multivalent ions [11]. In contrast, monovalent ions enhance the dispersion and spread of clay. Due to the complex interactions between clay and ions, the aggregation and transport of cohesive clay are expected to be largely impacted by the amount and type of ions in water [11].

2.4 Electric double-layer

When the particle is negatively charged, it attracts positive cations from the solution. This layer of cations is tightly bound to the surface and such layer is called the Stern layer, as shown in **Figure 2**. The cations in the Stern layer further attract anions in the solution that are less strictly adhered to the clay. This layer of anions is called the diffuse layer. The surface charge, Stern layer, and diffuse layer constitute the electric double-layer (EDL) [12]. EDL plays a critical role in the electrostatic stabilization of colloids and is fundamental for colloid stability and transport [13].

The interactions between EDLs play a critical role in particle aggregation and dispersion, and as a result, the factors that impact EDL will impact particle aggregation, dispersion, and transport. The surface potential of clay and the disjoining pressure among clay are two commonly used parameters that characterize the electric potential on the surface of a particle and the electrical interactions among two clay particles. Both parameters are related to EDL and are impacted by many factors including clay surface charge, the distance between clay particles, the polarization of water, and the ions in the solution. Surface potential is influenced by the surface charge and the separation between surfaces when EDLs overlap. In addition, according to the Poisson-Boltzmann theory, the polarization of water molecules and counterions influences how ions/water interact with the soil particle surface and can cause a reduction in surface potential. The midpoint potential between colloidal particles decreases with increased ion polarization [14].

Furthermore, the electrostatic part of disjoining pressure is linked to the interactions of the layer (EDL). Water molecule and counterion polarization impact the relationships between ions/water and soil particle surfaces, which impact the disjoining pressure. Water molecule polarization enhances pressure among soil particles whereas counterion polarization diminishes it. The interactions within the EDL affected by water and counterion polarization have a significant impact on how soil colloidal particles come together or separate and their transport [14]. Furthermore, the EDL is impacted by the types of ions in water. Divalent ions have been found to decrease the double-layer thickness, which could lower the colloid surface potential

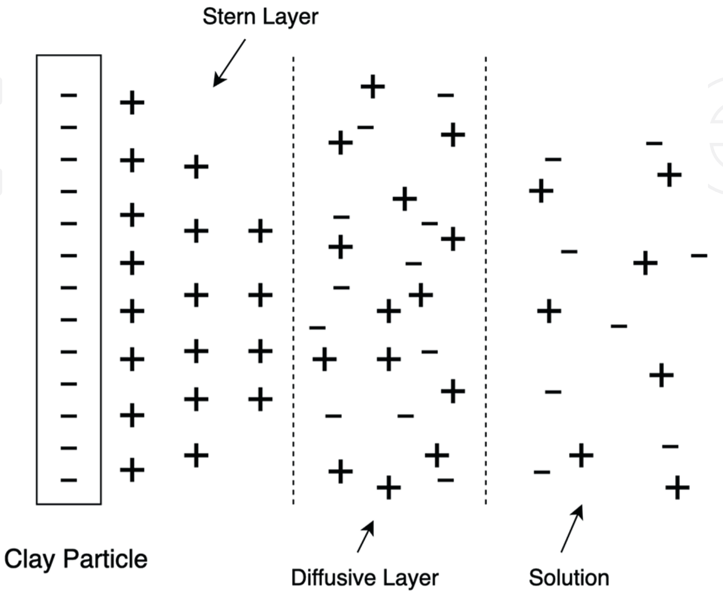

Figure 2.
Schematic diagram of the electrical double layer surrounding a negatively charged clay particle. The size is not to scale.

and impact colloidal transport. Knowledge of the impact of ions on EDL and clay disjoining pressure could be used to improve understanding of the role of salt on clay aggregation, dispersion, and transport. However, current knowledge of the EDL of clay and the nano- to microscale clay interactions remains incomplete, making it difficult to understand how salt impacts clay aggregation, dispersion, and macroscale transport. In the next sections, we present studies demonstrating how salt impacts clay and cohesive sediment transport at the macroscale.

3. Salinity and sediment transport

Salts have been shown to impact the transport of cohesive sediment at the macroscale (centimeter to meter scale). Such impact can be attributed to the large surface charge and area of clay and its ability to adsorb cations and form an EDL, as described above. In this section, we summarize papers that discuss how salinity impacts cohesive sediment transport. Salinity (g/L) is a key parameter that represents the total mass of dissolved salt in a liter of water. Salinity has been shown to impact the coagulation and stability of clay Edzwarld et al. [15], the growth rate and shape of the aggregates, and settling velocity [16], as discussed below.

First, Edzwarld et al. [15] studied the connection between ionic strength and the coagulation of suspended clay minerals through laboratory experiments and field investigation. For laboratory experiments, they mixed three types of clay minerals (kaolinite, illite, and montmorillonite) with buffer solution at ionic strength ranging from 0.03 to 0.3 M. Afterward, they placed the solution in a reactor with a stirring shaft that generates controlled shear and measured the number of particles under shear using microscopic counting as a function of flocculation time. Their study shows that the number of particles decreases with increasing flocculation time, which is on the order of 10 minutes. They further show that the number of particles decreases faster with increasing ionic strength, suggesting that an increase in ionic strength increases the flocculation of these three types of clay. From their number of particles versus the time curve, they determined the stability factor based on a mathematical model developed by Smoluchowski [17]. Specifically, Smoluchowski [17] described the aggregation of particles due to the movement of the fluid.

$$\frac{dn}{dt}=\frac{-4\Phi\alpha\,Gn}{\eth}\tag{1}$$

Here, n is the concentration of particles at time t, α is the stability factor, ϕ is the volume of colloidal particles per unit volume of suspension, and G is the root mean square velocity gradient. This equation demonstrates that the aggregation of clay particles is controlled by the shear as well as the stability of the factor, α. Edzwarld et al. [15] estimated α based on the measured n versus t curve for these three types of clay mixed with a solution at various salinity, and their laboratory experiments show that α increased by 2–4 times for all three clays when the ionic strength increased from 0.05 to 0.3 M. They further show that this trend held across solution compositions whether it was buffered NaCl solutions or synthetic estuarine solutions. This finding emphasizes an influential connection between ion concentration and the rate of coagulation.

In addition to laboratory experiments, Edzwarld et al. [15] collected sediment samples from the Pamlico River Estuary, which has a salinity ranging from 0.5 ppt in

Washington to 16 ppt at the mouth of the river. Afterward, they determined the type of clay minerals in the sediment samples using X-ray diffraction analysis. They also measured the number of particles in a reactor with a stirring shaft, from which they estimated the stability value α . Their results show that the stability factor of the field clay samples increased by 2–4 when salinity increased from 0.04 to 0.3 M. This result further confirms that salinity plays a critical role in clay coagulation.

In addition to coagulation and stability factors, salinity has been found to impact the size and shape of clay colloids as well as how fast they deposit. Abolfazli and Strom [16] conducted laboratory experiments to investigate how changes in salinity impact the aggregation of three types of clay: kaolinite, natural mud, and natural mud without organic matter (treated with sodium hypochlorite). The experiments were conducted in a 13-L mixing chamber, and turbulence was generated by a stirrer motor connected to a paddle, which allowed for adjustment of the mixing rate and turbulent shear rate (G) within the chamber. The mixing chamber had a camera system integrated into its setup to measure the size of particles or flocs. This system consisted of an LED source placed inside the tank and an external camera that captured images of particles passing through the opening created by the light source and tank wall. The camera system is capable of capturing flocs ranging from 5 to 1500 μm in size. The sizes of these particles or flocs were determined by extracting their projected two-dimensional area (A_f) using the formula $df = \sqrt{\frac{4A_f}{\pi}}$ where d_f represents the diameter or size. To generate size distributions based on both volume and size statistics like d_{50} (which represents the floc size by volume) the identified particles were categorized into log-sized bins. Abolfazli and Strom [16] measured d_{50} at various ionic strength and shear rates. In addition, they calculated the growth rate of the flocs as the changes in d_{50} during a short period (D_t) after a stepwise decrease in turbulent shear rate. Based on the size and growth rate measurements, they found that for mud with and without organic matter, an increase of salinity by 1–3 ppt can decrease the number of non-flocculated particles and increase floc size. Their study indicates a strong interaction between organic matter and salt, which needs further investigation.

In addition to the flocculation stability, salinity has been shown to impact the size and speed at which sediment particles settle, key parameters that control suspended sediment transport [18]. In this study, cohesive-suspended sediment was sampled from the Severn Estuary, high shear was first applied to break down these sediments, and then low shear was applied to suspend the particles for two hours. Afterward, the distribution of particle sizes and the settling velocity of the particles were measured using particle image velocimetry and image processing techniques. The results showed that sediment particles tend to clump when there is a higher concentration of sediment, but this change in the size of the flocs is not affected by changes in salinity levels. The speed at which particles settled ranged from 0.2 to 1.2 mm/s and was influenced by both the concentration of suspended sediment and salinity levels. The study discovered that in saltwater when sediment concentration is higher, the proportion of larger flocs increases. However, at lower salinity levels (<2.5 ppt), this proportion decreases by 7%. When salinity is low (2.5 ppt), the settling velocity increases with increasing suspended sediment concentration. However, at higher salinity levels (20 ppt), the floc settling velocity decreases with increasing suspended sediment concentration. The research suggests that salinity plays a key role in the setting of suspended sediment.

Krahl et al. [18] conducted a study to explore the role of salinity and extracellular polymeric substances (EPS) on the settling behavior of smectite clay, Wyoming bentonite. The main goal was to determine the coagulation concentration (CCC) needed for bentonite to start forming flocs in saline water. The researchers used the following three setups: differential settling experiments to measure CCC, settling time standard hydrograph analysis to study grain size distribution, and jar test experiments to compare floc size and settling behavior of bentonite with and without xanthan gum (a substitute for EPS). Sodium chloride was used to adjust the salinity and simulate neutral pH conditions in riverine waters. The findings indicated that even a small amount of salinity causes aggregation. For aggregates with a size of 184.8 μm, a settling speed of 2.0 mm/s was measured. When EPS was added to bentonite in saltwater, the aggregate sizes increased and settled faster than those without it. They further suggest that salinity is the trigger of flocculation, while EPS can further increase aggregate size. These findings further highlight the importance of salinity in influencing how particles clump together and the settling of these particles, as well as the complicated interactions among organic matter and salts. Investigations of the interactions between organic matter, salt, and clay minerals are needed yet currently lacking.

4. Sodium-adsorption ration and sodicity

In addition to salinity, the sodium absorption ratio (SAR), which is the amount of sodium Na relative to calcium (Ca) and magnesium (Mg) in water extract from saturated soil, plays a significant role in sediment erodibility, yet its role has been under-researched [1]. Soils with high SAR cause the clay to have higher water absorption and high porosity, which could lead to high erodibility. Parwada et al. [19] investigated how various physical and chemical factors affect the erosion rate of soils, including the SAR. They prepared clay samples with varying compositions of pore fluids. These samples were compressed into tubes and allowed to expand before being tested in a rotating cylinder apparatus. Then they placed the samples in a rotating cylindrical device and measured the erosion rate under different shear stresses. The results suggest that the types of cations, for example, monovalent versus multivalent, have a noticeable impact on sediment erodibility, yet such impact remains to be quantified.

Sodicity, defined as high sodium ion concentration compared to other cations in soil, has been used to characterize the impact of sodium on soil erosion. When soil structure starts to get impacted because of high sodium concentration, we call it sodic soil. Parwada et al. [19] collected soil samples from the Ntabelanga area in Eastern Cape province, South Africa, and analyzed the SAR, clay dispersion ratio, and other analyses to reveal a correlation ratio with land loss. The study found that clay presence contributes to soil stability, soils with more sand or silt tend to be more erodible. Soil sodicity, on the other hand, was measured by exchangeable sodium percentage (ESP) and SAR parameters, indicating that it can have an impact on soil erosion. However, in the Ntabelanga area, the sodicity level was low, and it was not the main cause of soil erosion, compared with other factors such as the soil organic carbon content. Such observations further highlight the importance of organic-salt interactions in clay erodibility.

Knowledge about the role of salts on erosion is particularly important for countries like Australia, where the salinization of water and land is significant and has been shown to cause land loss. It has been estimated that about 5.7 million hectares of soil in Australia are at stake and up to 20,000 km of streams are estimated to be affected 17 years from now [20]. Previous studies have linked high sodium levels with increased erosion and sediment transport, yet little evidence exists to support the relationship between sodicity and soil erodibility [20]. Ghadiri et al. [20] conducted a study that compared two soils with different characteristics, one with and another one without sodium. The research investigates the effects of soil salinity and sodicity, on soil erodibility, sediment transportation, and water quality downstream. Through measurements of erosion in simulated rainfall conditions on two soils in Queensland, it was observed that sediment loss increased when the soil was treated with sodium. These observations suggest that higher sodicity can lead to a weakening of soil aggregates and that the type of ions plays a critical role in sediment and soil erosion.

Like sodicity, Singer et al. [21] investigated the effects of Exchangeable Sodium Percentage (ESP) on soil erodibility in the Colusa Basin drain. They conducted three experiments using a rainfall simulator in their laboratory. The experiments involved eroding samples of soil types, such as Colusa silt loam, Pescadero, Sacramento A horizons, Contra Costa silty clay loam, and Hillgate loam. To measure ESP, Singer et al. experimented using soil samples, prepared soil batches, and applied leaching solutions with varying ratios of NaCl and $CaCl_2$. These solutions were then used to wash moistened soil samples weighing 1100 grams each. After leaching the amount of sodium was determined, in the soil. For Hillgate soil, the values were 16, 42, 69, and 80%. For Contra soil, the values were 19, 42, 75, and 81%. To remove salts from the samples a solution containing 95% ETOH was used, which was confirmed by conducting an $AgNO_3$ test on the leachates. The actual ESP was determined by displacing sodium, with NH_4 acetate. To ensure uniformity in the effect of leaching solutions divalent cations were first removed using Na acetate before leaching the soil using solutions that contain Ca and Na ions. Soil loss, soil detachment, and runoff volume were measured to assess how ESP influences soil erodibility. They first observed that lower ESP values (4) in Colusa silt loam resulted in a reduction of 20–24% in soil loss compared to high ESP values (54 and 73) [21]. These results highlight the impact of exchangeable ions on soil erosion.

Carlin et al. [22] conducted a field investigation in the Gulf of Mexico to examine the salt wedge's movement and the sediment's transport from the Brazos River to the Gulf of Mexico. A salt wedge is a layer of salt or seawater below fresh water. They measured salinity and turbidity and collected bottom topography and seismic data to investigate how a salt wedge interacts with suspended sediment in the Brazos River. To profile the water column, CTD (conductivity, temperature, and depth) and OBS (optical backscatter sensors) probes were deployed to measure the salinity and suspended sediment concentration during research expeditions in 2007, 2010, and 2012. The concentration profiles measured by OBS both longitudinally and vertically were analyzed to create a model representing sediment concentration across the river section. A mass balance analysis was carried out to estimate changes in transport from loads to the Gulf of Mexico. Their results show that the salt wedge modulates the transport of suspended sediment. Specifically, they show that when river discharge is low, it results in a salt wedge that captures sediment and creates a decimeter-thick mud layer. These field investigations further emphasize the important role of salt in modulating the transport of cohesive sediment, especially in estuaries where freshwater and saltwater meet.

5. Salinity and clay gelatinous status

San Juan et al. [23] investigate how salinity impacts the erosion threshold and microstructures of smectite clay. The study examined the erosion threshold of clay using an oscillating-grid tank having an oscillating grid moving up and down to generate a range of shear stress and turbulent kinetic energy. They tracked the movement of a synthetic smectite clay, laponite, using a laser sheet and a digital camera. In addition,

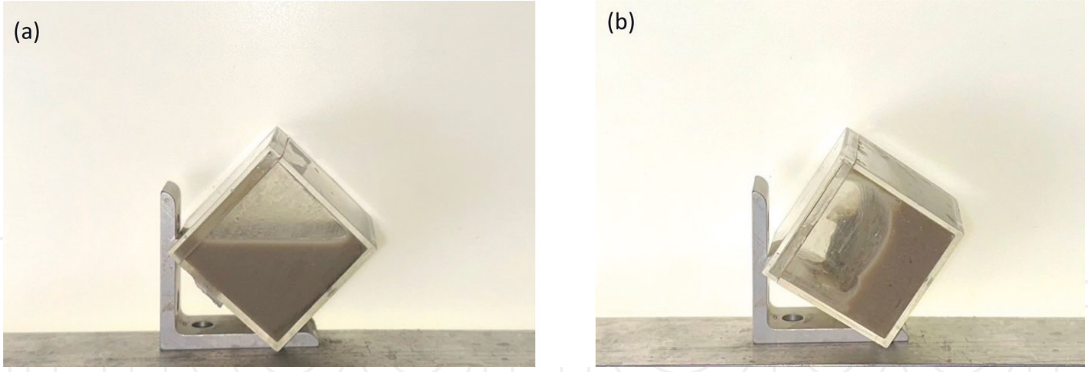

Figure 3.
Pictures of bentonite samples prepared at salinity 0 ppt (a) and 35 ppt (b). The sample was tilted by 30° to illustrate the gel or liquid states.

they directly measured the shear stress and turbulent kinetic energy using particle image velocimetry. They gradually increased the shear and identified the critical shear stress to erode the clay. The experiments were repeated at seven water salinities ranging from 0.1 to 10 ppt, as well as two different consolidation states. In addition to erosion measurements, they measured the yield stress of the clay samples using a rheometer.

Furthermore, they imaged the microstructure of the clay under various salinities using a confocal laser scanning microscope. The study discovered that the erosion threshold of the smectite clay increased by more than 10 times as the salinity increased from 0.15 to 1.5 ppt. However, when the salinity was higher than 1.5 ppt, the changes in erosion threshold with increasing salinity were not significant. They further show that the change in the dependency of erosion threshold on salinity coincided with a transformation in the microstructures of the clay. Specifically, at a salinity of less than 1.5 ppt, the clay is from a gel, and as such to erode the gel, the internal bonds of the gel must be broken down. They anticipate that the internal strength of the gelatinous clay network increases with increasing salinity, which is why the erosion threshold increases with increasing salinity. At salinity larger than 1.5 ppt, the clay becomes isolated aggregates. The erosion of these aggregates does not require the internal bonds of the gelatinous network to be broken down, which is why salinity plays a less important role in controlling the erosion threshold. Our recent study also shows that bentonite clay forms a gel at low salinity and becomes liquid-like at high salinity, as shown in **Figure 2**. They further show that given time to consolidate the erosion threshold of the clay doubled due to alterations in its microstructures. However, the impact of consolidation was much smaller than the impact of salinity. These findings emphasize the crucial role of salinity in controlling clay microstructures, rheological properties, and the onset of erosion (**Figure 3**, [23]).

6. Discussion

The studies outlined above offer valuable insights into the aggregation, settling, and erosion behaviors of cohesive sediment-containing clay under diverse salt conditions. However, quantitative predictive models for cohesive sediment transport remain lacking, especially under varying salt conditions. Most of the present studies do not control the mineral composition and the clay content in the sediment, making it difficult to develop quantitative measures of the role of clay on cohesive sediment transport. Moreover, cohesive clay often harbors significant amounts of organic matter and biological components, further complicating predictions of cohesive sediment transport. Therefore, additional research is needed to comprehensively understand how factors, such as clay content, mineral composition, and organic and biological constituents interact to influence cohesive sediment transport under varying salt conditions.

7. Conclusions

This chapter reviews the connection between salt and the movement of cohesive sediment with a focus on clay minerals. First, we discuss the characteristics of clay minerals including their classifications, size distribution, surface area, charges, and EDL. Compared with non-cohesive sand, the large surface area and surface charge of clay minerals contribute to their cohesiveness. The interactions between clay minerals and salt contribute to the dependency of clay and cohesive sediment transport on salt. We also delve into the formation of the layer EDL around clay particles and how this layer influences particle aggregation and dispersion.

In addition to clay minerals, we review studies that explore how salinity affects the transport of sediment. Specifically, we discussed how salinity influences the coagulation, stability, size variations, and settling speed of clay aggregates. Furthermore, we discuss how the SAR and sodicity impact sediment erodibility. These studies emphasize the role of ions such as sodium in regulating soil erodibility across soil types. Furthermore, we discussed a paper that investigated the influence of salinity on the microstructures and erosion threshold of smectite, which reveals a nuanced relationship between salt concentration and clay characteristics. Research has shown that raising the salinity level from 0.15 to 1.5 ppt can increase the erosion threshold of clay by more than 10 times. Similarly, an increase in the SAR from 4 to 73 can lead to a reduction in soil erosion by around 20–24%. These findings underscore the role of salt in regulating sediment movement.

This chapter provides perspectives on how salt interacts with clay particles and their transport in water systems. The various research works summarized in this chapter underscore the important role of salt in controlling clay properties and cohesive sediment transport. A fundamental understanding of particle characteristics, such as clay surface areas, surface charge, and EDL is key to understanding how salt impacts clay transport. More research is needed to improve the fundamental understanding of the impact of salt on the interactions among clay primary particles and the transport of clay and cohesive sediment.

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