

# Research Article **Physicochemical Properties of Bottom Sediments in Maruba Dam Reservoir, Machakos, Kenya**

# Allois Luvai (),<sup>1</sup> John Obiero (),<sup>2</sup> and Christian Omuto ()<sup>2</sup>

<sup>1</sup>School of Agricultural Sciences and Agribusiness, Pwani University, Kilifi, Kenya <sup>2</sup>Faculty of Engineering, University of Nairobi, Nairobi, Kenya

Correspondence should be addressed to Allois Luvai; kioko.allois@gmail.com

Received 20 March 2022; Revised 20 May 2022; Accepted 24 May 2022; Published 16 June 2022

Academic Editor: Upaka Rathnayake

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Bottom sediments form an integral part of the aquatic ecosystem, where they serve as important sinks for contaminants. However, management options for bottom sediments require an analysis of the physical and chemical properties. Therefore, the aim of this study was to assess the physicochemical properties of bottom sediments in the Maruba dam reservoir in order to inform their potential use. The bottom sediments were obtained from three sampling points using a vibe-coring device. The samples were analyzed for grain size, sediment bulk density, pH, electrical conductivity, organic matter content, and nutrient content (nitrogen, phosphorous, and potassium) using standard laboratory procedures. The results of the study revealed that the bottom sediments were predominantly clay (56%). The mean pH value of the sediments was 6.63, which was found to be slightly acidic. The concentration of cations and anions in the bottom sediments was found to be quite high, with a mean value of 0.225 dS·m<sup>-1</sup>. The bottom sediments in the reservoir were found to be quite rich in the organic matter content (2.10%) and had a mean bulk density of 0.620 g·cm<sup>-3</sup>. The macronutrients (nitrogen, potassium, and phosphorous) had mean values of 0.12%, 0.46%, and 12.81 mg·kg<sup>-1</sup>, respectively. The study established that finely grained particles together with organic matter had a potential effect on the availability of macronutrients in bottom sediments. The concentration of the macronutrients of the bottom sediments were availability of macronutrients in bottom sediments. The concentration of the macronutrients of the bottom sediments.

# 1. Introduction

Water is an important natural resource that supports life for every living thing on the globe [1]. However, the availability of water in the right quantity and quality has been a challenge for many third-world countries. This challenge has awakened the call for the development and prudent management of available water resources for sustainability [2]. More specifically, this recognition has led to development of ways of storing water, especially across rivers through the construction of reservoirs [1, 3]. Water storage is an ancient strategy that has served to sustain humankind for many generations. Reservoirs have been established for the purpose of providing water for irrigation, flood control, water supply, recreation, and power generation among others [3, 4]. However, many reservoirs in many developing countries are unable to meet their functions because of sedimentation problems [4, 5]. Limnology studies have proved that natural processes have an influence on the loss of storage capacity for reservoirs due to human influence and climate change [6]. Land use and land cover transformations have accelerated the movement of matter and energy in such ecosystems, the worst being sediment deposition in reservoirs and lakes [6]. Recently, climate change-related impacts have been increasing. For instance, changes in rainfall patterns have led to increased cases of soil erosion, leading to an increase in sediment and pollutant supply in reservoirs and lakes [7]. Population growth has resulted in increased generation of sediment and nutrients that find their way into streams and rivers and eventually into reservoirs and lakes [8]. Despite sedimentation being a natural process, it may be decelerated by adopting soil and water management strategies and better agricultural techniques within catchment areas [3]. On the other hand, the removal of silt is a much more involving task because of technological challenges and above all, environmental, social, and ecological considerations [9].

Sediments may be deposited or appear in suspension form. In healthy reservoirs, a balance is struck between sediment influx and that which supports aquatic life. Inorganic sediments are compounds that accumulate in reservoirs over years due to anthropogenic activities [10]. On the other hand, trace elements are important indicators that serve to document how anthropogenic activities influence reservoirs and lakes [6]. The aquatic environment is largely affected by trace elements that contaminate sediments and eventually threaten the existence of living organisms. Elevated sediment quantities in reservoirs lead to depleted oxygen levels because they promote plant and algae growth. Suspended sediments reduce light penetration in the reservoir, hence affecting the health of aquatic life. Deposited sediments, on the other hand, reduce the habitable environment for aquatic life by filling up the spaces between rocks. The type, composition, and quantity of sediments in reservoirs are determined by the catchment characteristics, prevailing climate, and residence time [9].

Detailed geophysical surveys typically provide useful information for understanding modern sedimentary activities and catchment processes in a variety of geological settings, as well as their impact on sediment distribution in the receiving body [11]. The geochemical properties of sediments allow the determination of factors and processes which influence the occurrence of elements and their distribution [12]. Sediments serve as vital nutrient carriers while also encouraging plant and algae growth [9, 13]. Sediments in reservoirs are either inorganic (silt, sand, and clay) or organic (remains of living things) form and are adsorbed by nutrients and contaminants, where most of them are a threat to the sustainability of reservoirs [14]. Total organic carbon is used to quantify the organic matter content present in sediments, while nutrients are expressed as total nitrogen and total phosphorous [13]. Increased demand for food and feed has forced many farmers to rely on inorganic and organic fertilizers as a way of fixing important nutrients (mainly nitrogen and phosphorous) into the soil. However, plants do not utilize the nutrients entirely, and the remnants are rejected into the environment [15]. On the one hand, breakdown of organic matter leads to reduced sediment carbon, while on the other hand, nutrient concentrations are released to the water column from the sediment.

Bottom sediments are critical elements in water bodies. The water environment in most reservoirs and lakes is quite dynamic despite being characterized by interactions and interplay between physical, chemical, and biological properties of bottom sediments [9]. Basically, bottom sediments found in water bodies are fine-grained or even extremely fine-grained and are mostly fine sands, silt, and clay particles [7, 9]. The biotic life of the aquatic environment is largely dependent on the physicochemical nature of the reservoir. Reservoir properties help to clearly understand the relationship between natural processes and the activities within the reservoir. Hence, better choices are made to ensure protection [12]. Physical properties describe the nonuniformity and complexity of reservoirs. The actual physical factors, particularly the shape, depth, and temperature of water, influence the circulation of water and sedimentation. The chemical properties of sediments provide critical information on eutrophication rates in reservoirs [15].

Studies on reservoir bottom characteristics for the Maruba dam reservoir have not been carried out. Moreover, such studies are very seldom in Kenya. The objective of this study was to determine the physicochemical properties of bottom sediments in the Maruba dam reservoir. The study will provide important information regarding the actual state of the bottom sediments in the reservoir. Furthermore, these data would enhance policies regarding sustainable management of the dam catchment and reservoir operations, among others [1].

## 2. Materials and Methods

2.1. Description of the Study Site. The study was carried out in the Maruba dam reservoir, which is located in Machakos town, Machakos County, Kenya (Figure 1). The dam is fed by the Maruba stream, and it serves as the main water source for Machakos town and its immediate environment. The management of the dam is the responsibility of a water service provider in the town: Machakos Water and Sewerage Company Limited. The Maruba stream is largely seasonal, and it experiences fluctuating flows during rainy spells. The dam catchment area is approximately 49 km<sup>2</sup> and is defined by  $37^{\circ} 12' 0''$  to  $37^{\circ} 20' 0''$  E and  $1^{\circ} 24' 0''$  to  $1^{\circ} 34' 0''$  S. The catchment fluctuates between 2120 m (Iveti Hills) and 1580 m (dam reservoir) above sea level.

2.2. Sediment Sampling. Bottom sediments in the Maruba dam reservoir were sampled in the month of October 2021. The samples were collected using a sediment core sampler, which was operated from a twin boat [16, 17]. Sediment coring was done at three predetermined points distributed over the dam reservoir. The distribution of points was based on sediment depth established using acoustic profiling system data [18]. The penetration depth of the core tube was monitored using acoustic data recorded by the bathymetric survey system. The first step in the collection of sediment cores was securing the boat in position by anchoring it at three points. The vibe-coring device was carefully lowered in a vertical position with the help of a winch up to a point when no movement was noted with the core tube. This was an indication that the core tube had reached a compacted sediment layer. The sediment core samples were retrieved and handled according to the procedure described by [19].

2.3. Bottom Sediment Analysis. Sediment samples were subjected to sun-drying for about two days and thereafter air-dried at room temperature conditions for quite a few days [17, 20]. Any unrecompensed form of matter found amidst the sediments was carefully removed, after which the content was mixed uniformly [21]. After drying, the samples were ground manually and passed through a 2 mm sieve



FIGURE 1: Location map for the study area.

separately [20, 22]. The samples were carefully stored for further laboratory tests. The Maruba dam reservoir is located in an agricultural watershed, and therefore, the sediment quality would have been affected by nonpoint pollution emanating from croplands. Therefore, the samples were analyzed for nutrients [23]. Analysis of bottom sediments was performed to determine total nitrogen (N), phosphorus (P), and potassium (K). Other parameters included grain size, pH, electrical conductivity, and organic matter content.

Textural analysis was carried out using the hydrometer method where the particle size distribution (PSD) was established [24]. The pH and electrical conductivity of the bottom sediments were measured using an HQ40D portable multiparameter meter. Before any measurements were obtained, the sediment samples were prepared according to the procedure highlighted by [21]. Soil sediments have many organic compounds, most of which vary chemically and structurally [25]. The organic matter content in soil has a direct effect on its fertility, particle size, and aggregation [26]. Organic materials have a yellow-brown to black colour, which means that when the sample is too dark, the higher the organic matter content [27]. However, this approach serves as a rough estimate of the organic material content in a soil sample. Different methods have been used to estimate the organic matter content. These include colorimetry, the combustion method, and titration, among others [25, 27]. Moreover, the organic matter content may be estimated by first establishing the organic carbon present in a soil sample, after which the value is multiplied by a constant value (1.724) [25]. In this study, organic carbon (OC) in the sediments was determined using the rapid wet oxidation method. The protocol by [28], which was later modified and well described by [29], was followed. The total organic carbon was multiplied by a factor of 1.724 to obtain the organic matter (OM) content in the sediments (TOM) [25, 30]. Both phosphorous and potassium were determined using the ICP-OAS method, while nitrogen content was determined following the Kjeldahl method [31].

## 3. Results and Discussion

The physicochemical properties of reservoir bottom sediments have a strong influence on the diverse hydrophysical and biogeochemical processes that take place in the catchment areas [23, 32]. Furthermore, the chemistry of bottom sediments determines the characteristic properties and probable participation in water body processes that relate to pollutants, heavy metals, biogenic elements, sorption/desorption of organic matter, and probable use in agriculture [12, 33]. Hence, knowledge about the physicochemical composition of reservoir bottom sediments is an important step in the management of reservoirs and in assessing their suitability for any potential use. Research has demonstrated that bottom sediments have been used in various areas that touch on the economy worldwide: agriculture [22, 23, 31, 33], environmental engineering [34], reclamation of nonagricultural land [35], and civil engineering [5, 36]. Table 1 provides the results of the physicochemical analyses of bottom sediments in the Maruba dam reservoir.

3.1. Textural Analysis. Sediment is a product that results from erosion processes where soil disintegrates into sand, silt, clay, and organic matter, which upon transport, settles in water bodies [36]. Sediment deposition is quite evident in water bodies, and it is known to be comprised of very many combinations of different particle classes that range from fine to coarse material [36]. In this regard, textural analysis is arguably an important procedure that helps to clearly understand the provenance of sediment transport history as well as depositional environments [37]. The relative proportions of sand, clay, and silt are given in Table 1. The bottom sediments in the reservoir were predominantly clay and sand particles. The textural class of the bottom sediments was clay. According to the study, the proportions of sand, clay, and particles in bottom sediments were nearly the same with no major significant differences (Table 1). Hence, the textural analysis did not show any geological diversity in the catchment area [7]. However, the presence of clay particles in bottom sediments in a reservoir can be used as a suitable ecological indicator for describing the land use pattern in a catchment [38]. The dominant grain particles in the reservoir could explain the level of soil disturbance within the catchment area and the eventual soil erosion effect. Dislodgement of clay particles is much more than that of sand particles, and this may be due to seasonal fluctuations in flow conditions that bring about distinguishable energy conditions inside the reservoir [33]. The higher clay content could also have resulted from urban runoff in the neighborhood of the dam reservoir [37, 38] associated the high content of finely grained sediments (clay and silt) in the Dukan dam reservoir with reduced flow energy, which described a quieter and calmer depositional environment.

Typically, the particle size distribution of sediments experiences longitudinal variation, where coarse sediment, mainly sand and coarse silt, dominates the upstream region, while fine grains, mostly silt and clay, accumulate in the deep sections and near the dam wall [39]. As a matter of fact, the beneficial use of bottom sediments will differ on the basis of grain size. Thus, it is pertinent to understand the spatial variation of sediments inside a reservoir, as this will help in developing an appropriate plan for their management [40]. According to Wyrwicka et al. [41], finely grained bottom sediments are quite rich in both mineral nutrients as well as organic matter, and therefore, they can serve as fertilizers. On the other hand, sandy sediments may serve as important agricultural substrates, while those with higher clay composition may be incorporated into soils as a way of enhancing poor quality soils, especially sandy ones [33]. According to Tarnawski [34], the productivity of sand soils may be increased by the use of bottom sediments, since they improve the water retention capacity of such soils.

3.2. Sediment Bulk Density. Bulk density in sediments measures the degree of compaction, which cannot be indicated by grain size analysis [42]. Wiesebron et al. [42] further pointed out that the range of sediment bulk density experiences some spatial orientations. This proposition was well explained by the sediment bulk density values in this study (Table 1). Statistically, quite compacted sandy sediments have bulk density values that range from 1 to  $2 \text{ g·cm}^{-3}$ , while softer sediments that have higher mud content have bulk density values that range from 0.2 to  $1.5 \text{ g·cm}^{-3}$  [43]. In this study, bottom sediments were found to be quite muddier, and therefore, the mean bulk density was found to be within the reported range ( $0.620 \pm 0.015 \text{ g·cm}^{-3}$ ).

3.3. Sediment pH. The pH of the bottom sediments had a mean value of 6.63. According to Boyd [30], the pH range in lakes has a range between 4 and 9, and therefore, the study's results were found to range in the same bracket. Similar results for pH in reservoirs have been reported by different researchers [13, 22, 38]. The average pH value of sediments in the Maruba dam reservoir was found to be slightly acidic, and this was an indication of additives and nutrients in the soil [44]. The acidic conditions could probably be due to the acidic nature of organic matter and also high levels of aluminum and iron oxides [33]. A pH test for bottom sediments attempts to relate the occurrence of aquatic life in diverse environmental conditions [21, 45]. Thus, pH is an index that reflects the conditions associated with nutrient release, the physical state of the soil, and the effects of toxic substances [46]. Hence, pH plays an important role in establishing the quality status of sediments [13, 26]. The differences in pH are not significant, and therefore, they cannot be considered to indicate land use patterns in the catchment [38]. Thus, the pH condition in the reservoir could have prevailed because of the good balance between the organic matter content and organic carbon from agricultural production and forest land use in the catchment [13]. Furthermore, Table 1 provides that the fluctuation of pH values was between 6.5 and 8.5, which are the recommended limits for the sustainability of aquatic life [47]. Therefore, the pH values for the bottom sediment implied that the activities that cause catchment degradation were relatively limited, as were the erosion processes since they contribute significantly to alkalinity in sediments and water bodies [48].

3.4. Electrical Conductivity. Water reservoirs fall under the category of hydraulic structures that frequently reflect human settlements, industrial, as well as agricultural activities [49]. These hydraulic structures are quite sensitive to

TABLE 1: The mean values of the physicochemical properties.

Sampling	(%)						лЦ	$(g \cdot cm^{-3})$	$(mg \cdot kg^{-1})$	$(dS \cdot m^{-1})$
point	Sand	Clay	Silt	Ν	Κ	OM	pm	sBD	Р	EC
1	$39.79 \pm 1.88$	$55.61 \pm 2.09$	$4.60 \pm 1.74$	$0.13\pm0.02$	$0.47\pm0.02$	$2.15\pm0.12$	$6.64\pm0.12$	$0.621 \pm 0.016$	$12.58 \pm 1.93$	$0.223\pm0.5$
2	$40.00\pm0.94$	$56.11 \pm 1.94$	$3.89 \pm 1.61$	$0.13\pm0.11$	$0.46\pm0.02$	$2.10\pm0.72$	$6.63\pm0.09$	$0.614\pm0.016$	$13.02 \pm 1.49$	$0.224\pm0.05$
3	$39.44 \pm 1.02$	$57.22\pm0.75$	$3.33 \pm 1.15$	$0.12\pm0.01$	$0.44\pm0.01$	$2.05\pm0.17$	$6.62\pm0.11$	$0.625\pm0.013$	$12.83 \pm 1.2$	$0.23\pm0.04$

TABLE 2: Correlation matrices between physicochemical properties of bottom sediments of Maruba reservoir.

	Sand	Clay	Silt	Ν	Κ	ОМ	sBD	pН	Р	EC
Sand	1.000									
Clay	-0.526	1.000								
Silt	-0.269	-0.677	1.000							
Ν	0.159	-0.593	0.534	1.000						
Κ	-0.190	0.042	0.117	0.203	1.000					
OM	0.092	-0.009	-0.070	0.187	0.439	1.000				
sBD	0.225	-0.019	-0.173	-0.106	-0.520	-0.488	1.000			
pН	-0.257	-0.218	0.470	0.473	-0.008	-0.344	0.110	1.000		
P	0.336	-0.230	-0.030	0.100	-0.165	0.313	-0.094	-0.560	1.000	
EC	0.203	-0.283	0.145	-0.029	-0.702	-0.485	0.413	0.175	0.026	1.000

significant chemical and biological changes, especially the shallow ones. Streamflow dynamics have a direct relationship with bottom sediments, which ultimately influence the hydrochemistry of the reservoir [50]. Electrical conductance is a parameter that quantifies the number of dissolved solids in substances. Conductivity is a test that is used to determine the degree of mineralization of a substance [51]. An imbalance of ions in soil or water brings about some physiological disorders in plants and animals. The average electrical conductivity value for bottom sediments in the Maruba dam reservoir was found to be 0.225 dS·m<sup>-1</sup>. Similar results were reported by [13] in their study in Lake Tana, Ethiopia. Pagenkopf reported that the electrical conductivity values of most natural waters range from 0.05 to  $0.5 \,\mathrm{dS} \cdot \mathrm{m}^{-1}$ , while highly mineralized ones have values as high as  $1 \text{ dS} \cdot \text{m}^{-1}$ . In this regard, the mean electrical conductivities for both sediment types indicated that the Maruba dam reservoir was under moderate anthropogenic pressure [49]. The study established that electrical conductivity was the highest in the deeper layers of the reservoir. This was an indication that deeper layers of bottom sediments have a higher concentration of cations and anions [52].

3.5. Organic Matter Content. The interface between sediment and water is an important region because it influences a variety of processes in different bodies of water [39]. This surface is subject to deposition by allochthonous and even autochthonous organic material [53]. Accumulation of organic matter is periodic up to a point where it attains steadystate conditions depending on accumulation and sedimentation rates. The amount of organic matter in sediments is reported to influence some basic properties, adsorption capacity, among others. The mean value of the organic matter content in the reservoir was found to be 2.10% (Table 1). The medium range of organic matter for general soils is between 2% and 7% [44]. However, sandy sediments have relatively low organic matter content, with less than 2% [7]. According to Griggs [54], sediments whose values of the organic matter content exceed 1% are described as being organically rich. On this basis, therefore, the bottom sediments in the Maruba dam reservoir were termed organically rich. Basically, the addition of organic matter onto the bottom soil's surface is by sedimentation that occurs in the reservoir [53]. The reservoir could have been characterized by a high energy level, hence an increased rate of allochthonous organic matter in the reservoir system [13, 33]. Some probable sources of organic matter in the dam reservoir include agricultural and forestry activities in the catchment area [55]. Urban runoff is also reported as an important source of organic matter in the dam reservoir [56]. The study established that the deeper layers of sediment were disconnected from the supply of organic matter. These layers lack dissolved oxygen, which promotes sediment decomposition and nutrient recycling [38]. The decomposition of organic matter leads to the increased carbon content in the sediments [26]. As a consequence, both organic carbon (OC) and organic matter (OM) in bottom sediments are considered critical ecological parameters that indicate the patterns of land use in the upper reaches of a dam catchment [38]. High levels of organic matter content in sediments translate to a high total nitrogen content, which is an indication of the good health of an ecosystem [57]. Organic matter leads to an increase in cation exchange that aids in the breakdown of nonliving algae in the reservoir bottom, where oxygen gas is consumed and toxic gases such as carbon dioxide, hydrogen sulfide, and ammonia are liberated [30].

*3.6. Macronutrients.* The mean potassium, nitrogen, and phosphorous content of the Maruba dam reservoir bottom sediments were 0.46%, 0.12%, and 12.809 mg·kg<sup>-1</sup>, respectively. According to Matej-Łukowicz et al. [58], these values

were quite low compared to one-component or even multicomponent fertilizers. The level of macronutrients in the reservoir suggests increased anthropogenic activity in the catchment area [59]. Some probable causes of the evaluated nutrient level could have been domestic and urban waste from the neighboring Machakos town. Furthermore, surface runoff from agricultural lands may have introduced pollutants such as fertilizers and pesticides into the reservoir. Therefore, the Maruba dam reservoir is probably subjected to immense pollution and biogenic compounds.

The study revealed that the macronutrient contents were found to be higher near the dam wall; similar observations were made by [22]. This phenomenon was probably occasioned by the movement of water in the reservoir during flood periods. Furthermore, the concentration of micronutrients in the bottom sediments was found to be quite high in the top sediment layers [60]. This is because most nutrients appear in large quantities in the topsoil layers that are comprised of finely grained particles that are washed away by surface runoff [20].

Organic matter with regards to sediments is described as a reservoir for nutrients where it holds and binds them together, thereby ensuring that they are not permanently available [13]. The nitrogen content in bottom sediments provides critical information about the quality of sedimentary organic matter [61]. The level of nitrogen in bottom sediments is therefore associated with high levels of protein in the organic matter [13, 61]. The high content of protein in organic matter results from the activities of aquatic organisms and the decomposition of plant and animal remains. The phosphorous content from inorganic sources, particularly from agricultural-related activities (phosphorous fertilizers), is exceedingly low when compared to organic sources [13]. Phosphorous does not exist in gaseous form, and therefore, a phosphorous cycle does not exist, like in the case of nitrogen. Thus, as a nutrient, phosphorous accumulates in bottom sediments and is released very slowly into the reservoir water upon oxidation of organic matter [62].

Bottom sediments with low concentrations of macronutrients (N, P, and K), organic carbon, and trace elements can be used to supplement arable land quality and productivity [39]. In instances where bottom sediments are found to be rich in terms of nutrients as well as organic carbon, they can be substituted for inorganic fertilizers in croplands [63]. In this regard, Karanam et al. [63] demonstrated that bottom sediments have not only environmental benefits but also economic ones. The nutrient concentration of bottom sediments in the Maruba dam reservoir compares well with results from similar studies by [33, 64, 65], where bottom sediments were recommended for agricultural use and reclamation. According to Matej-Łukowicz et al. [58], the direct use of bottom sediments as fertilizer should not be encouraged, but instead, enrichment with nitrogen and organic carbon is strongly recommended. As a matter of fact, bottom sediments do not match a typical fertilizer mixture, although they contain some valuable elements such as iron and sulfur [58]. The biggest shortcoming with bottom sediments in their probable use in an agricultural context is the low phosphorous concentration, which is described as a nonrenewable resource. Hence, the potential use of bottom sediments in agriculture should be pursued after enrichment has been carried out [58]. Based on the argument by [39], the bottom sediments in the Maruba dam reservoir could potentially be used in agricultural activities in the catchment area and to improve the degraded land around the dam reservoir.

3.7. Correlations. The characteristics of the bottom sediments, especially particle grains, organic matter, and pH, have an influence on the electrical conductivity and concentration of the macronutrients in the sediments. A moderate correlation was observed between nitrogen (N) and silt. Similarly, weak correlations were noted between potassium (K) and clay and silt particles and nitrogen (N); pH and silt particles and nitrogen (N); total organic matter and sand particles, nitrogen (N), and potassium (K); phosphorous and sand particles; and electrical conductivity (EC) and sand particles, silt particles, sediment bulk density, pH, and phosphorus. Table 2 provides that nitrogen probably adsorbs on silt particles and to a lesser extent on sand particles, while potassium does on organic matter. Likewise, organic matter was confirmed as the main pathway for phosphorous delivery to bottom sediments [65]. Similarly, acidic cations may have adsorbed on silt particles, and this would explain the correlation between silt particles and sediment pH. Therefore, finely grained particles and total organic matter parameters potentially affect the availability of macronutrients in reservoir bottom sediments.

#### 4. Conclusions

- The physicochemical properties of bottom sediments were largely influenced by the agricultural activities in the catchment area, as well as the urban settlements in the nearby Machakos town
- (2) The bottom sediments in the dam reservoir had very high clay fractions (56%), were found to be slightly acidic (pH of 6.63), and had a mean organic matter content of 2.10%. In addition, the mean electrical conductivity value for the sediments was 0.225 dS·m<sup>-1</sup>, while the bulk density was 0.620 g·cm<sup>-3</sup>.
- (3) The mean nitrogen, phosphorous, and potassium concentrations were 0.12%, 0.46%, and 12.81 mg·kg<sup>-1</sup>, respectively. These nutrient values suggest the possible use of the bottom sediments in agriculture and the reclamation of degraded lands in the dam reservoir catchment.
- (4) As shown by the correlation analysis, particle size distribution is a critical parameter that serves as a diagnostic characteristic of bottom sediment type. This is because electrical conductivity and the concentration of macronutrients (N, P, and K) are strongly influenced by the characteristics of bottom sediments, particularly particle size and organic matter.

## **Data Availability**

The data used to support the findings of this study are included within the article.

#### **Conflicts of Interest**

The authors declare that they have no conflicts of interest.

#### Acknowledgments

The study was funded under a PhD scholarship program provided by the Ministry of Agriculture, Livestock, Fisheries and Cooperatives through The Kenya Climate Smart Agriculture Project (KCSAP), a World Bank project in Kenya.

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