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Richard Haynes *Editor*

Pollution and Its Minimization

Proceedings of the 2022 10th International Conference on Environment Pollution and Prevention

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Richard Haynes
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Preface

We are honored to bring you this proceeding from the 2022 10th International Conference on Environment Pollution and Prevention (ICEPP 2022) which was successfully held between December 16 and 18, 2022 in Sydney, Australia in hybrid form.

ICEPP 2022 is dedicated to issues related to environment pollution and prevention. This annually-held conference is a great program that provides a forum for professors, researchers, scholars and industrial pioneers all over the world to share ideas, reflect past accomplishments, renew friendships and extended networks, and jointly explore current and future research directions. The conference received more than 80 papers during the submission period and more than 45 individuals attended the conference from a range of countries and regions.

The conference model included two parts: physical session and virtual session. This conference is highlighted by Conference Committee, Keynote Speakers. Prof. R. J. (Dick) Haynes from The University of Queensland, Australia did the Opening Remarks. Professor Dennis Y. C. Leung from University of Hong Kong, Hong Kong, China and Prof. Yu Hong from Beijing Forestry University, China shared their keynote speeches. There were five sub-sessions with various interesting topics as follows: Water Quality Analysis and Waste Water Treatment; Environmental Pollution and Control; Urban Planning, Green Design and Environmental Economics; Environmental Biology and Ecological Environment Management; Water Pollution Treatment and Soil Pollution Remediation.

ICEPP2022 conference proceeding is a valuable record of the conference which presents a selection from papers submitted to the conference from universities, research institutes and industries. All the papers have been through a rigorous peer-reviewed process in order to meet international publication standards. The proceeding is mainly divided into the following chapters: Water Pollution Analysis, Wastewater Treatment and Water Resources Management; Ecological Protection and Sustainable Development; Traffic Emission Monitoring and Air Pollution Assessment; Building Environment, Emission Reduction and Life Cycle Assessment; GIS and Earth Resources Survey; Environmental Biology and Biological Response to Environmental Stress.

We are herewith extending the thankfulness to those who supported ICEPP 2022. Especially, we would like to thank the valuable inputs of the scientific committees, reviewers, keynote and invited speakers, presenters, as well as conference organizers, which were of great importance to the success of conference. We believe that the proceedings can serve as a reference, and hopefully inspire new ideas for scientists, engineers, students, equipment manufacturers and operators, as well as technical managers who are working on the broad field of environment pollution and prevention.

Gatton, Australia Prof. Richard Haynes

Contents

Part I Water Pollution Analysis, Wastewater Treatment and Water Resources Management

1 Metal Ion-Doped MnO_2 Used in CDI 3
Chao Wang, Nelson Erwin, Zerui Lin, Christopher Samuel Ah-Low, Su Xu, and Wenchao Liao

2 Design and Implementation of a WWTP by Active Sludge System at Laboratory Scale, Faculty of Livestock Sciences ESPOCH 11
Lucrecia Llerena, Mayra Llerena, Nancy Rodríguez, and Solange Tite Llerena

3 Inexact Joint-Probabilistic Stochastic Programming Model (ITIC-JPC) Synergy MCDA Analysis on Water Allocation in Jimei District of Xiamen City 25
Yi Wei, Lei Jin, Zhen Liu, Xi Zhang, Ruoyu Yin, and Pangpang Gao

4 Effects of Properties of Montmorillonite on the Formation of Oil-Mineral Aggregates 37
Wenxin Li, Yajing Qi, Wei Wang, Deqi Xiong, Zhixin Qi, and Yue Yu

5 Study on the Performance of Cobalt Removal by Manganese-Based Capacitive Deionization 47
Han Liu, Tao Zhang, Su Xu, ChaoWang, and Yaling Zhang

Part II Ecological Protection and Sustainable Development

6 Multitemporal Analysis of Riverbank Areas in the Central Peruvian Andes 59
C. Alvarez-Montalvan, E. Belito-Humani, R. Caballero-Salas, E. Vila-Villegas, J. M. Alomia-Lucero, and C. Parra-Vasquez

7 Ecological Rehabilitation Indicators of the Brownfields Site of Nenzi Refinery in Taiwan 69
Fu-Rong Zheng and Shih-Jen Feng

8 Quantification of the Carbon and Biomass Content of a Remaining Forest of Polylepis Spp. In the Peruvian Andes 83
O. R. Cordova-Cordova, M. R. Rivera-Campano, M. I. Castañeda-Tinco, C. E. Alvarez-Montalvan, J. M. Alomia-Lucero, and Y. Rojas-Castillo

9 Adoption of Sustainable Energy Management Systems Among Healthcare Institutions in Malaysia: A Conceptual Paper 99
David Frank Ahimaz, Kuan Siew Khor, and Pei Boon Ooi

10 Sustainable Community Center for Research and Dissemination of Environmental Biodiversity in the Pamplona Hills—San Juan of Miraflores—Peru 2022 109
Doris Esenarro, Vanessa Raymundo, Julia Fernandez, Julio Figueroa, and Hardy Ventura

Part III Traffic Emission Monitoring and Air Pollution Assessment

11 Simplified Gaussian Model at Ground Level and PM10 Effluent of Industry Plumes, South Pan-American Highway, Pisco 131
Pedro Córdova-Mendoza, Teresa Barrios-Mendoza, Erwin Peña-Casas, Edgar Peña-Casas, Isis Córdova-Barrios, Jhohans Ochante-Alejos, and María Ruiz-Casanova

12 Evaluation of Using Dust Suppressants to Reduce Road Suspended Dust (PM_{10}) in South Korea 151
Hojun Yoo, Gyumin Yeon, Jeongyeon Cho, Sungjin Hong, and Intai Kim

13 Study on Fine-Grained Traffic Pollution Monitoring in Urban Area 167
Xin Peng, Runzhe Liu, Feilong Yang, and Yi Wen

Part IV Building Environment, Emission Reduction and Life Cycle Assessment

14 Green Infrastructure, Urban Heat Islands and Human Well—Being in the City of Metropolitan Lima 181
Pedro Amaya, Oscar Cuya, Doris Esenarro, Violeta Vega, and Raul Mendez

15 Research on Emissions Reduction Strategy of Wind Turbine Based on Life Cycle Assessment 197
Wanchao Wang and Jiaxing Shi

Part V GIS and Earth Resources Survey

16 Urban Land Cover Change from 1986 to 2020 and Potential Expansion in the Mantaro Valley, Central Peru 213
M. I. Castañeda-Tinco, C. E. Alvarez-Montalvan, V. H. Pariona-Antonio, J. C. Alvarez-Orellana, R. I. Laredo-Cardenas, and J. M. Alomia-Lucero

17 Application of Mapping Remote Sensing Technology and GIS in Geological Exploration 233
Hongguo Huang, Xiaolei Liu, Luqi Liu, Yiqing Pan, Jiangshuai Jing, and Xiaolu Duan

Part VI Environmental Biology and Biological Response to Environmental Stress

18 Microbial Response Mechanism of Soil Inorganic Nitrogen Characteristics to Organic Fertilizer in Flue-Cured Tobacco Field 247
Yuzhou Jiang, Shunhui Chen, Wenqing Li, Qingli Liu, Zhihong Li, Yungui Zhang, Yan Zhang, Sijia Li, Xu Wang, and Xinya Zhao

19 Lethal Effects and Behavioral Responses of Sea Cucumber (*Apostichopus Japonicus*, *Selenka*) to Thermal and Hypoxia Stresses 259
Yuhang Zou, Wei Yang, Xishan Li, Deqi Xiong, and Guoxiang Liao

Part I
Water Pollution Analysis, Wastewater Treatment and Water Resources Management

Chapter 1
Metal Ion-Doped MnO_2 Used in CDI

Chao Wang, Nelson Erwin, Zerui Lin, Christopher Samuel Ah-Low, Su Xu, and Wenchao Liao

Abstract Capacitive deionization (CDI) is one of the most promising techniques compared to other desalination techniques. Manganese dioxide (MnO_2) has been applied as electrode material due to the high capacitance, low price but limited by low conductivity. In this study, transition metals (Fe, Ni, and Co) have been doped on MnO_2 to improve the electrode conductivity. The materials were characterized by XRD, SEM, EDX, and BET, the electrochemical properties were conducted by CV measurement, and the desalination efficiency was measured by a batch model. The results show that Ni@β-MnO_2 has the highest ion removal rate.

Keywords CDI · Manganese dioxide · Doped MnO_2

1.1 Introduction

Desalination of brackish water to produce drinking water has attracted more attention due to exponential human growth (Shannon et al. 2008). Some desalination methods have been studied, for example, reverse osmosis (RO) (Fritzmann et al. 2007) and nanofiltration (NF). But the high energy consumption and membrane fouling restrict their application. CDI is a low-cost desalination technique, which absorbs ions from a solution by two electrodes (Huang et al. 2016). The core of CDI technology is electrode materials. At present, many new materials (mainly carbon materials, conductive polymers, and their complexes) have been used as CDI electrode materials. Manganese dioxide (MnO_2), due to the high capacitance and natural abundance, has a positive impact on CDI but is limited by low electrical conductivity and low crystallinity (Gan et al. 2019). In recent years, manganese dioxide complex has been

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studied, such as MnO_2 and carbon composite (Dong 2017), MnO_2 and high polymer materials, and transition metal in MnO_2 (Feng et al. 1995). However, the MnO_2 electrode possessed low electrocatalytic activities due to poor electrical conductivities. The research confirmed that the conductivity of MnO_2 could be improved by metal ions (Fe, V, Co, and Ni) doping. Moreover, MnO_2 has more than 30 crystal phases; β-MnO_2 is one of the most valuable and could be considered electrode materials for CDI.

This paper aims to develop high desalination effect materials based on the doping of metal ions (Fe, Co, and Ni) on β-MnO_2, thus maximizing the advantages of the two materials to improve the characteristics of manganese dioxide as electrode materials.

1.2 Experimental Section

All chemical reagents were purchased from Sigma-Aldrich, Aladin and used as received. All experiments were performed in triplicate.

1.2.1 Material Synthesis

The various MnO_2 powders were synthesis by the hydrothermal reaction, β-MnO_2 was synthesized by dissolving 1:1 mol ratio of Manganese Sulfate ($MnSO_4$) and Potassium Permanganate (($KMnO_4$) in 60 ml DI water, then the mixed solutions were transferred into a 100 ml Teflon-lined stainless steel autoclave under 150 °C for 10 h. The precipitation was washed with DI water and dried in the oven for 12 h.

Synthesis of M(=Fe, Co, Ni) doped β-MnO_2 was almost the same as the procedure described above, except that add a fraction of metal ions ($Fe_2(SO_4)$, $Co(NO_3)_2$, and $NiSO_4$ with three different Mn(II)/M molar rations (1:0.5).

The electrode was fabricated by using Ti-plate (5*5 cm) as substrates; the paste was prepared by mixing as-synthesized MnO_2 and carbon black (CB) with Polyvinylidene difluoride (PVDF) in weight ratios (5:3:2), then dissolved in N-Methyl-2-pyrrolidone (NMP) under agitated for 48 h. after the paste spread over Ti-substrate, the electrode was dried at 80 °C for 10 h to evaporate all organic solvents, which remained in the electrode pores.

1.2.2 Material Characterization

The structure of as-synthesized MnO_2 was identified by XRD (Cu Kα radiation λ = 0.15418 nm, 10−90°), the morphology was measured by using SEM (JSM700F-JEOL), and the chemical compounds were analyzed with EDs. The specific surface area of the materials was determined by the Bennet–Emmett–Teller (BET) method (WBL-830 specific surface area and porosity analyzer).

1.2.3 Electrochemical Measurement

The electrochemical properties of as-synthesized MnO_2 were performed by CV under a three-electrode system using a Zennium 2.0 electrochemical workstation (Zahner), with as-prepared MnO_2 electrode as the working electrode, carbon electrode as the counter electrode and in 10 mM NaCl solution. The specific capacitance (C in F/g) of materials was calculated with CV curve under follow Eq. (1.1).

$$C = \frac{S}{2vUm} \tag{1.1}$$

where C = Capacitance (F/g), S = Absolute area, V = Scan rate (V), U = Voltage (V), m = Mass (g).

1.2.4 CDI Test

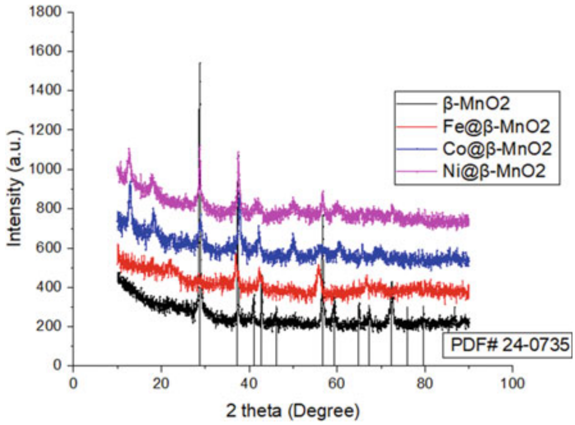
The CDI efficiency was determined by a batch-model CDI experiment. The CDI cell was fabricated with an as-prepared MnO_2 electrode (cathode), and a carbon counter electrode (anode) separated at a distance of 2 mm by 3 M tape as spacers. The experiments were conducted at −1.2 V (cathode) in 50 ml 1.0 mM NaCl solution. The conductivity before and after the desalination process was recorded using a conductivity meter.

The ion removal capacity (η in mg/g) and ion removal rate (r in mg/gs) were calculated with the equation below Eqs. (1.2) and (1.3), where C_o and C_i are the salt concentration of sodium chloride at the beginning and the end of the ion removal experiment, respectively, V as in the equation is the volume of sodium chloride being tested, and M_{tot} is the mass of the manganese oxide and activated carbon electrode.

$$\eta = \frac{(Co - Ci) * V}{Mtot} \tag{1.2}$$

$$r = \frac{(Co - Ci) * V}{Mtot * s} \tag{1.3}$$

Fig. 1.1 XRD patterns of doped β-MnO_2 with mol ratios of 1:0.5



1.3 Results and Discussion

1.3.1 Characterization of β-MnO_2 Doped with Different Metals

Figure 1.1 shows the comparison of XRD pattern of β-MnO_2 and metal ion-doped β-MnO_2. The diffraction peaks matched well with standard card PDF 24-0375 in 29°, 39°, and 58°, which could be identified with β-MnO_2. The addition of metal ions decreased and shifted the diffraction intensity and peaks; moreover, a new peak in 12° present for Co- and Ni-doped materials indicated the change of β-MnO_2 due to the doping process.

The morphology of pure and doped MnO_2 was illustrated by SEM in Fig. 1.2, and the β-MnO_2 is composed of nanoneedle aggregates; the doped MnO_2 possessed nanowire morphology, the observation indicated that the addition of metal ions reformed the morphology of β-MnO_2. Combined with the EDS elemental analysis, which is shown in Fig. 1.3, it can be seen that Fe, Co, and Ni exist in the as-synthesized material, indicated the metal ions had been successfully doped into MnO_2.

The specific surface area of β-MnO_2 and doped β-MnO_2 is shown in Table 1.1. The results indicated that doping process could improve the specific surface area of materials, and Fe@β-MnO_2 possessed the highest specific surface area.

1.3.2 Electrochemical Property

The electrochemical properties of the obtained nanocomposites were studied through CV analysis. Figure 1.4 shows the CV performance of the pure β-MnO_2 and doped β-MnO_2 electrodes in a three-electrode model with the scan rate of $30mVs^{-1}$ in

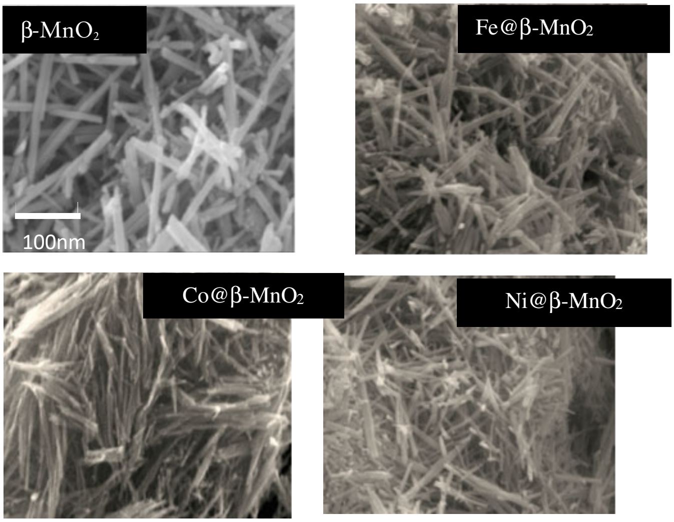


Fig. 1.2 SEM images of as-synthesized MnO_2

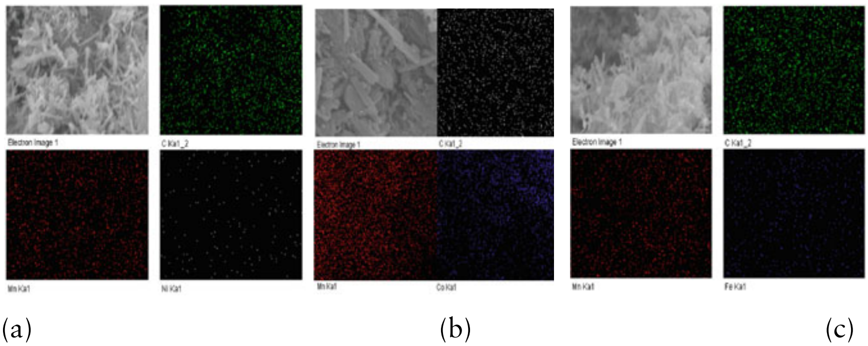


Fig. 1.3 EDX mapping of doped MnO_2: **a** Fe@β-MnO_2 **b** Co@β-MnO_2 **c** Ni@β-MnO_2

Table 1.1 Specific surface area and specific capacitance of pure and doped β-MnO_2

Name	Specific surface area (m^2/g)
β-MnO_2	25.688
Fe@β-MnO_2	84.326
Co@β-MnO_2	33.132
Ni@β-MnO_2	34.169

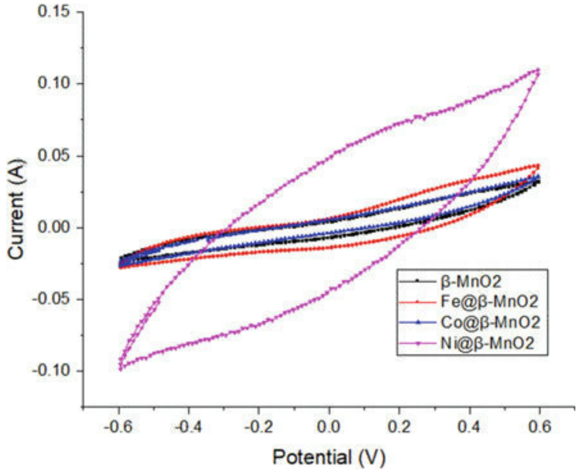


Fig. 1.4 The comparison between CVs of pure and doped MnO_2 at $30 mVs^{-1}$ in 10 mM NaCl

10 mM NaCl. Compared with other electrodes, Ni@β-MnO_2 shows a larger leaf form curve, suggesting an ideal pseudocapacitive behavior and a higher capacitance value.

1.3.3 CDI Performance

In the CDI experiment, MnO_2 electrodes and carbon electrodes were used as cathode and anode. The desalination performance of pure and doped β-MnO_2 was evaluated with ion removal capacity and ion removal rate; the results are shown in Table 1.2. Among all electrodes, the Ni@β-MnO_2 possessed the highest ion removal capacity and ion removal rate, which indicates that Ni@β-MnO_2 can quickly capture sodium ions through surface adsorption and surface oxidation–reduction reactions and provide a suitable path for the diffusion of ions. The high removal ability of the electrode may also be related to the lower resistivity, which matches the results of CV. Therefore, Ni@β-MnO_2 material has excellent desalination ability.

Table 1.2 Ion removal capacity and ion removal rate of different materials

Materials	Ion removal capacity (mg/g)	Ion removal rate (mg/(g s))
β-MnO_2	0	0
Fe@β-MnO_2	399.113	0.111
Co@β-MnO_2	239.468	0.067
Ni@β-MnO_2	1250.554	0.347

1.4 Conclusion

Fe/Co/Ni-doped β-MnO_2 were synthesized through hydrothermal reaction and used as CDI electrode materials. Through electrochemical analysis and desalination experiments, Ni@β-MnO_2 shows excellent ion removal capacity and has achieved high desalination efficiency, which is very suitable for the research and development of high-performance CDI.

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Chapter 2
Design and Implementation of a WWTP by Active Sludge System at Laboratory Scale, Faculty of Livestock Sciences ESPOCH

Lucrecia Llerena, Mayra Llerena, Nancy Rodríguez, and Solange Tite Llerena

Abstract The wastewater treatment using activated sludge is considered an aerobic biological treatment method, being one of the most efficient strategies for organic matter removal. In this study, the experimental investigative method was used, which consisted of five stages, first the collection of information, then the sampling of wastewater in the slaughterhouse of the San Pedro de Pelileo canton, then the characterization of the effluents, fourth the execution of calculations for the design of the wastewater treatment plant (WWTP) and finally the verification of the efficiency of the system. The design of the WWTP on a laboratory scale is made up of three tanks: storage, aeration and sedimentation with extensions of 60 × 60 × 85 cm and two tanks: collection of treated water and sludge with extensions of 60 × 60 × 70 cm. The treatment was carried out varying the hydraulic retention times (72–36–12–4 h), respectively. As a result of the treatment, the elimination of the biochemical oxygen demand (BOD) was modified with an initial value of 29,500 to 300 mg/L in a hydraulic retention time of 2 h. It is concluded that the biological treatment carried out in the laboratory-scale WWTP is excellent in terms of efficiency to remove contaminants since the sedimentable solids were eliminated in 99.9% of the effluents from the slaughterhouse.

Keywords Activated sludge system · Slaughterhouse · Effluent quality · Hydraulic retention

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2.1 Introduction

Ecuador has approximately 300 slaughterhouses, most of which are municipally concentrated in urban areas, of which 70% are in the Sierra. According to the Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP) (Kist et al. 2009). The meat industry represents an important link in the country's economic system (Benka-Coker and Ojior 1995). The slaughterhouses of Ecuador can self-satisfy their demand for consumption, mostly beef. Due to the high demand for meat consumption in Ecuador, the exponential growth of the waste produced from the slaughter processes has been evidenced. The inadequate management of liquid waste from slaughterhouses puts environmental resources at risk (Fan et al. 2021).

The Slaughterhouses are the meat industry facilities that generate the greatest impact on environmental resources (Amorim et al. 2007). The main liquid waste generated by slaughterhouses is blood, manure, fat, urine and other materials such as heads, feet and parts of the animal that are not consumed (Antunes et al. 2021).

The Slaughterhouse pollution is associated with negative impacts on the environment. The amount of residual matter present in animal slaughter waste influences the behavior of standard water quality index (ICA) in natural resources (Jasim 2020).

A wastewater treatment plant from a slaughterhouse requires considering in its design the removal of contaminant levels from water quality parameters such as: biological oxygen demand (BOD), chemical oxygen demand (COD), oils and fats, suspended solids, fecal coliforms, among others (Sideney et al. 2017).

The removal of organic matter involves secondary treatment systems such as activated sludge systems, which contribute to generating value-added inputs from biomass or residual sludge (Orssatto et al. 2017).

The main advantage of implementing an activated sludge system in wastewater treatment is the high efficiency of contaminant removal (Chang and Lee 1998). In addition, the water that passes through the activated sludge system and meets the water quality index (ICA) is reused in other slaughterhouse activities (Ng et al. 2022).

The main objective of this study is to design and implement a wastewater treatment plant (WWTP) using activated sludge systems on a laboratory scale at the Faculty of Livestock Sciences of Higher Polytechnic School of Chimborazo (ESPOCH). The information collected from the design parameters visualizes the behavior of the activated sludge system on the wastewater from the slaughterhouse. The behavior of the activated sludge system determines the efficiency of the system to reduce organic matter from the effluents.

The present study benefits future research related to the quality of wastewater from slaughterhouses. The constant monitoring of the quality of the residual water allows to maintain a rigorous control of the quality of the water for its discharge. The quality of the residual water for discharge is subject to compliance with the permissible limits according to the Unified Text of Secondary Legislation of the Ministry of the Environment (TULSMA).

This document is organized as follows: Sect. 2.2 presents the methodology; Sect. 2.3 describes the results and discussion. Finally, Sect. 2.4 presents the conclusions and future research.

2.2 Methodological Study

Next, the methodology that describes the phases for the execution of activities related to the design and implementation of a WWTP by active sludge system at laboratory scale in the Faculty of Livestock Sciences of the Higher Polytechnic School of Chimborazo (ESPOCH).

2.2.1 Information Gathering

The information search was carried out through official scientific research sites such as Scopus, Web of Science, Journal of Environmental Pollution, Springer and Science Direct using keywords: slaughterhouse, activated sludge system, WWTP. In this way, a considerable list of recent articles related to the research topic was obtained.

On the one hand, the laboratory-scale construction of this project was carried out in the Instrumental Laboratory of the Faculty of Livestock Sciences, at the Higher Polytechnic School of Chimborazo. On the other hand, the characterization of the wastewater samples from the slaughterhouse was carried out in the Water Quality Laboratory of the Faculty of Sciences of Higher Polytechnic School of Chimborazo ESPOCH.

2.2.2 Wastewater Sampling Area

The place selected for taking the wastewater samples in this project was the municipal slaughterhouse located in the canton Pelileo Grande parish, which has been operating since 2014 with the financing of the Decentralized Autonomous Government of the San Pedro de Pelileo Canton, its production is approximately 600 animals between cattle and pigs. The slaughter center has an area of 4400 m^2 (see Fig. 2.1).

2.2.3 Characterization of Wastewater Before Plant Design

For the collection of the residual water sample, the punctual sampling method was used, 2 L of residual water were collected from the discharge area in a sterilized container, this sample was used for the respective physical, chemical and

Fig. 2.1 Geographical location of the Pelileo municipal slaughterhouse. This figure shows a satellite image obtained from Google Earth, georeferenced, where the extension of the study area is shown

microbiological analyses. The samples were immediately taken to the ESPOCH instrumental analysis laboratory, where each of the analyses was carried out. The following Table 2.1 shows the control parameters that were considered for the characterization of the slaughterhouse wastewater, as part of the control parameters, physical, chemical and microbiological analyses were carried out, the main parameters that were considered for the monitoring of the influent before treatment were: Dissolved Oxygen (OD), Biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, volatile solids, total solids, PH, temperature, dissolved oxygen and as part of the microbiological parameters fecal coliforms.

The wastewater from the slaughterhouse has a high load of contaminants, at a glance it was possible to appreciate parameters such as color and solids, these are indicators of water quality (see Fig. 2.2).

The analyses carried out before the treatment allowed the evaluation of the parameters established to evaluate the quality of the water. The measurement of solids was carried out using the gravimetric method. In the case of settleable solids, Imhoff

Table 2.1 Characterization results before treatment

Parameter	Units	Results	Allowable limit
pH	–	5.69	5–9
Temperature	°C	25.9	<35
OD	mg/L	1.15	–
COD	mg/L	32000	250
BOD	mg/L	29500	100
Suspended solids	mg/L	18558	100
Volatile solids	mg/L	15360	100
Total solids	mg/L	22300	1600
Total coliforms	UPC/mL	544000	Remove > 99,9%

Fig. 2.2 This figure shows the current state of the tributaries of the slaughterhouse of the San Pedro de Pelileo canton, you can see the discharge of wastewater, which has a cloudy appearance, the color shows the presence of blood in its content, as well as material leftovers from slaughtering processes

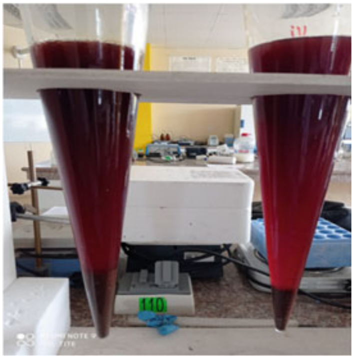

Fig. 2.3 This figure shows the process to determine settleable solids using Imhoff cones, a time of 20 min was used, two specific samples were taken to determine the quality of the sources before treatment with activated sludge

Cones were used (see Fig. 2.3). The visual appearance of the wastewater is an indication of the quality of the water (Xie et al. 2012). The color is a parameter that indicates the quality of the water and is related to the dissolved substances in suspension (Kahraman and Şimşek 2020).

The control parameters analyzed before treatment were assessed according to the permissible limits of the environmental quality and effluent discharge standard: water resource (Book VI Annex I) (Environmental Quality and Effluent Discharge Standard: Water Resources (2017).

The persistent and rigorous monitoring of wastewater discharge parameters focuses on physicochemical variables of the water in order to evaluate whether they comply with the values established in the discharge limits for a freshwater body. The physical chemical control parameters such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, settleable solids, volatile solids, total solids exceeded the ranges established in the current environmental regulations (Book VI Annex I) (Environmental Quality and Effluent Discharge Standard: Water Resources (2017).

The Maximum Permissible Limits (LMP) are the maximum admissible values of the representative parameters of water quality. The overflow of the LMP indicates the degree of severe contamination presented by the discharge of these waters on some water body in a natural state.

2.2.4 Design and Construction of the Plant on a Laboratory Scale

The design of the laboratory-scale activated sludge wastewater treatment plant was based on the previous characterization of the water. For the characterization of the wastewater, the following Table 2.2 presents 12 control parameters, mainly the biochemical influent oxygen demand (BOD), inlet volatile suspended solids (VSS), inlet total solids and inlet total suspended solids (TSS), effluent flow rate, mixed liquor volatile suspended solids (VSSLM), total solids concentration (TSC) and biokinetic coefficients.

For the design, a flow rate of 200 L/h was considered. The flow considered corresponds to 50% of the theoretical flow. The values of k, Y, kd were obtained from the laboratory through the operation of a pilot plant for the wastewater to be treated, under different treatment conditions, which allow obtaining the parameters required to quantify the values of the biological constants (Kapagiannidis 2018).

From the values obtained in the design, it was decided to consider 12% of the total dimensions calculated for the construction of the equipment; this decision was made for educational purposes (Kapagiannidis 2018). Prior to construction, a modeling of the WWTP operating system was developed, which consists of an aeration tank and a sedimentation tank (see Fig. 2.4). All this biological process is carried out in a first tank known as a biological reactor, where aeration is supplied to the wastewater. Subsequently, a secondary treatment is carried out, where this clarified water is reoxygenated and filtered for later reuse.

Table 2.2 Data for determination of design parameters

Parameter	Results	Units
BOD affluent	25300	mg/L
VSS entrada	13360	mg/L
Total solids	22400	mg/L
TSS affluent	18558	mg/L
BOD effluent	7075	mg/L
TSS effluent	6532.3	mg/L
Caudal effluent	5200	L/day
SSVLM	4200	mg/L
TSC	18000	mg/L
Kd (20 °C)	0.025–0.075	d^{-1}
K	25–100	mg/L DBO5