# Adsorption potentials of modified and unmodified bone and horn char in diminution of microbial mass of polluted water

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**ABSTRACT**

*Pathogenic organism in water has led to diverse health challenges, especially in developing and underdeveloped nations where knowledge and concern on water quality is low. This has further led to epidemic, as water is utilized in virtually all works of life. In this study, some microbial parameters in surface water samples sourced from residential and industrial areas were investigated prior to treatment and following treatment with modified and unmodified bone and horn chars. Biosorbents capacities were examined using Freundlich and Langmuir isotherms. The adsorption mechanism was equally investigated. Results obtained after discrete detention time shows that sorption of total fungal, aerobic and coliform was well described by both isotherms ($R^2$ > 0.98) based on water source and adsorbent type. The maximum adsorptive capacity of zinc modified chars was 2.0 × $10^6$ cfu/g for polluted surface water from industrial area. The pseudo-second-order kinetic model fitted the adsorption mechanism. Pretreated and unmodified chars from bone and horn have good adsorption capacities and resulted in significant pathogens reduction in polluted surface water.*

**Keywords: Adsorption, isotherm models, biosorbent capacity, bone and horn char.**

## 1.0 INTRODUCTION

Water is an indispensable constituent in all works of life. However, it is not readily available in some regions due to climatic conditions while in other areas it exists in contaminated form. Water pollution has been linked to anthropogenic activities. Dixit and Shanker (2009) traced the root of water pollution to urbanization and industrialization. Ojoawo *et. al.,* (2010) and Rajkumar *et. al.,* (2010) observed leachate and runoff from adjacent dumpsite as major pollutant of surface and ground water. The unrestraint action of solid waste and wastewater disposal have contributed basically to low proportion of water hygienically suitable for safe consumption, irrigation and other household activities. According to Szewzyk *et. al.,* (2000), only 2.6 % of available water is safe for drinking due to elevated levels of some parameters including pathogenic count. Moreover, most aquatic pathogens such as coliform and water-loving fungal are disease causal, posing high risk infection to man, fauna and flora. Such include gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases in man and fauna, as well as sour rot, bacteria blotch and several grain diseases in flora (USEPA, 1986; Smilanick *et. al.,* 2008). The primary means of transmittance to human and fauna hosts is via ingestion of contaminated water. Further means of transmission to hosts is by absorption, surface and skin contact with aerosolized water especially, during and shortly after a spray irrigation exercise. Therefore, there should be some measure of pathogens kill, diminution and check in contaminated water before usage. Dixit and Shanker (2009) recommended some treatment methods capable of combating this menace. One of such methods is chlorination, but was observed to be ineffective in some pathogens kill. Cardona (2006) suggested adsorption due to its proficiency in pathogens kill. Beyond this distinctive quality, it is simple, cost effective, non - carcinogenic and environment-friendly (USEPA, 2001; Bansal *et. al.,* 2009). Adsorption with granular activated carbon reduced the quantity of disinfectant employed for microorganism kill in water treatment before final distribution to consumers (Snoeyink and Summers, 1999). This results in cost reduction in potable water production. Rezaee *et. al.,* (2011) study achieved 99.9 % E.coli removal with bone char as biosorbent. Ijaola *et. al.,* (2013) also observed promising results in the adsorption of total fungal on bamboo char. These studies indicate that some low-cost biological materials can serve as biosorbents and be effective in pathogen removal. Apart from the availability of adsorptive materials, the evaluation of adsorptive capacity is a mandatory requirement for good sorbent selection (Yakubu *et. al.,* 2008). This study is focused on microbial adsorption potentials of biosorbents from abattoir solid waste. The Freundlich and Langmuir isotherm models are used as the probing tools for adsorption capacities. These models have been found useful in understanding the extent and measure of adsorption favorability by previous investigators.

## 2.0 STUDY AREA

The study was carried out in Ibadan, Oyo state, the south - western part of Nigeria. Sourced surface waters were classified under residential and industrial. Surface water from residential area was collected from a watercourse channeled through Yemetu while the contaminated surface water was sourced from a running river considered as discharge spot for most industries in Oluyole area. Precursors used as biosorbents were sourced from Bodija abattoir.

## 3.0 METHODS

Surface waters were collected upstream under stringent conditions with 10-liter plastics and capped bottles at dawn. The samples were transported under an iced condition to reduce temperature variation that might influence microbial growth. The respective microbial parameters such as total fungal, total aerobic and coliform were inspected in the laboratory according to standard methods.

Cattle bone and horn-bone were carbonized under deoxygenated condition at 450 $^oC$ and 400 $^oC$ respectively. Sample from both chars were partly crushed and washed with deionized water. One kilogram of each sample was impregnated with $ZnCl_2$ salt dissolved in 1L of distilled water. The solution was continuously stirred for 6 hrs after a detention period of 2 hrs. Another set of 1 kg of each sample was activated with $AlCl_3$ salt dissolved in 1L of distilled water. The solution was oven-heated to 80 $^oC$ and repeatedly agitated for 1 hr. Precursor to salts ratio was 2:1. Thereafter, the activated chars were cleaned with distilled water to remove anions, cations, adhering dirts and suspended impurities. All samples were filtered and oven-dried at 120 $^oC$ for 12 hrs. Biosorbents produced were bone char (bc) and horn chars (hc), aluminium modified bone (abc), aluminium modified horn chars (ahc), zinc modified bone (zbc) and zinc modified horn chars (zhc). The chars were crushed, sieved into particle size less than 850 micron to enhance sorption and then stored.

Water sample sourced from industrial area was passed over calibrated adsorption composite-columns of dimension 12×12×62 cm at apparently low flow rate to boost treatability. Each adsorber was underlaid with 15 g of dampened cotton-wool and contains 350g of the biosorbent only. Treated water samples were collected at 2, 4 and 6 hrs retention time for microbial mass determination. Wilson *et. al.,* (2001) suggested retention time above 1hr for maximum sorption to occur. Similar procedure was repeated for surface water sourced from residential area. Experimental processes were replicated and the average values computed.

## 4.0 EXPERIMENTAL CALCULATION

The linear form of Freundlich and Langmuir models and pseudo first and second-order kinetic models after integration with boundary conditions are expressed by Equations 1-6.

$$Q_t = (C_o - C_t)V_t/W_b \quad (1)$$
$$LogQ_t = Log\,K + (1/n)LogC_t \quad (2)$$
$$C_t/Q_t = -1/(Q_m.K_L) + C_t/Q_m \quad (3)$$
$$R_L = 1/(1 + K_LC_o) \quad (4)$$
$$Log(Q_e - Q_t) = LogQ_e - (K_Q/2.3038)t \quad (5)$$
$$t/Q_t = 1/(K_pQ_e{}^2) + t/Q_e \quad (6)$$

Where $Q_t$ represents the quantity of microbial parameter adsorbed per adsorbent unit weight at a particular detention time (cfu/g); $Q_e$ denotes the quantity of microbial parameter adsorbed per adsorbent unit weight equilibrium (cfu/g); $C_o$ signifies the initial concentration of microbial parameter before treatment (cfu/mL); $C_t$ represents the concentration of microbial parameter after treatment for a specific detention time (cfu/mL); $V_t$ stands for the volume of water in adsorption column at a specific retention time (L); $W_b$ is the mass of biosorbent (g); $t$ indicates detention time in hrs; $Q_m$ signifies the maximum adsorptive capacity of microbial parameter (cfu/g); $K$ is the Freundlich constant related to the extent of adsorption (cfu/g); $n$ is related to the adsorption intensity; $K_L$ is the Langmuir parameter related to the energy of adsorption (L/cfu) and $R_L$ is the equilibrium parameter expressing Langmuir isotherm. Values of $K$ and n are constants calculated from the intercept and slope of plot of $Log\ Q_t$ against $Log\ C_t$. $K_L$ and $Q_m$ are obtained from the intercept and slope of plot of $C_t/Q_t$ against $C_t$. Constants $K_Q$(L/min) and $K_p$ (g/cfu/min) are first and second-order pseudo rates.

## 5.0 RESULTS AND DISCUSSIONS

### *5.1 Organism Isolated*

*Bacillus spp, Pseudomonas sp, Proteus sp, Aeromonas sp, Aspergillus spp, Candida sp, Rhizopus sp and Geotrichum sp* were the microbes isolated prior to treatment and at post adsorption state.

### *5.2 Isotherm Model*

Over 90 % correlation coefficients ($R^2$) of both isotherm models for the adsorption of the microbiological parameters were greater than 0.98 (Tables 1-6). The Freundlich model has a better representation for coliform and total fungal sorption on all biosorbents for polluted surface water from industrial area ($R^2$ >

0.99). This result agrees with Lin *et. al.,* (2010) observation of *Ralstonia solanacearum* sorption on a virulent mutant strain ($R^2$ = 0.99). The $R^2$ values in Tables 1-6 depict the applicability of Freundlich and Langmuir isotherm models in describing pathogens attenuation based on water source and adsorbent type. The $Q_m$ values, required to form a monolayer obtained from Langmuir isotherms, show that the microbial parameters sorbed were within $2.49 \times 10^3 – 2.01 \times 10^6$ cfu/g range. This result is in line with Shan *et. al.,* (2013) study on ustiloxins produced by a pathogenic fungus of rice false smut disease and also Lin *et. al.,* (2010) findings. The maximum adsorption capacities of biosorbents were in this order; total fungal > total aerobic > coliform in polluted water from industrial area and total aerobic > total fungal > coliform in surface water around residential area. The polluted surface water from industrial area had higher $Q_m$ and $K_L$ values for coliform counts compared with polluted surface water from residential area (Tables 4-6). This is an indication of higher coliform adsorption for polluted surface water in industrial area. According to Amuda and Ibrahim (2006), high Freundlich equilibrium constant is indicative of bond energies between adsorbate and adsorbent, while k is a pointer of good biosorbent adsorbability. Significant value of n typifies biosorbent high rate of adsorption. The k values for zinc modified bone char were high in total aerobic and coliform sorption for polluted water in residential area. This implies that bone char pretreated with zinc chloride salt has high adsorption potential for total aerobic and coliform (Tables 1 & 2). The k and n values for the adsorption of total aerobic on bone char were greater than the values for horn char in surface water from residential area. The result indicates stronger affinity of bone char in the adsorption of total aerobic in polluted surface water from residential area (Table 1).

**Table 1: Freundlich isotherm constants and correlation coefficient for total aerobic sorption.**

| | Surface water (Industrial area) | | | Surface water (Residential area) | | |
|---|---|---|---|---|---|---|
| | $R^2$ | k | n | $R^2$ | k | n |
| **Horn char** | 0.8878 | 2.737 | 1.310 | 0.9930 | 1.19E3 | 0.774 |
| **Bone char** | 0.9985 | 2.5E4 | 1.686 | 0.9999 | 1.51E3 | 0.777 |
| **Aluminium modified horn char** | 0.9285 | 1.204 | 1.169 | 0.9962 | 2.99E3 | 0.832 |
| **Aluminium modified bone char** | 0.9345 | 9.1E1 | 0.881 | 0.9883 | 1.87E4 | 0.676 |
| **Zinc modified horn char** | 0.9997 | 1.869 | 1.042 | 0.9979 | 2.51E2 | 0.763 |
| **Zinc modified bone char** | 0.9999 | 3.0E1 | 0.856 | 0.9972 | 1.19E7 | 0.505 |

**Table 2: Freundlich isotherm constants and correlation coefficient for coliform sorption.**

| | Surface water (Industrial area) | | | Surface water (Residential area) | | |
|---|---|---|---|---|---|---|
| | $R^2$ | k | n | $R^2$ | k | n |
| **Horn char** | 0.9963 | 4.9E1 | 0.877 | 0.9694 | 1.36E4 | 0.620 |
| **Bone char** | 1 | 7.6E2 | 0.759 | 0.9989 | 2.92E2 | 0.805 |
| **Aluminium modified horn char** | 1 | 4.060 | 1.021 | 0.9993 | 1.08E1 | 0.939 |
| **Aluminium modified bone char** | 0.9999 | 1.190 | 1.082 | 0.9862 | 3.37E2 | 0.739 |
| **Zinc modified horn char** | 0.9998 | 2.440 | 1.106 | 0.9962 | 2.7800 | 0.963 |
| **Zinc modified bone char** | 0.9991 | 1.1E3 | 0.961 | 0.9963 | 6.04E6 | 0.454 |

**Table 3: Freundlich isotherm constants and correlation coefficient for total fungal sorption.**

| | Surface water (Industrial area) | | | Surface water (Residential area) | | |
|---|---|---|---|---|---|---|
| | $R^2$ | k | n | $R^2$ | k | n |
| **Horn char** | 0.9985 | 1.515 | 0.926 | 0.9812 | 3.65E2 | 0.789 |
| **Bone char** | 0.9989 | 3.421 | 1.037 | 0.9762 | 1.24E4 | 0.648 |
| **Aluminium modified horn char** | 0.9998 | 9.817 | 1.117 | 0.9976 | 1.56E4 | 0.520 |
| **Aluminium modified bone char** | 0.997 | 9.080 | 1.101 | 0.9934 | 3.130 | 0.929 |
| **Zinc modified horn char** | 0.9994 | 8.574 | 1.124 | 0.9895 | 3.58E2 | 0.676 |
| **Zinc modified bone char** | 0.9995 | 8.700 | 1.114 | 0.998 | 1.39E2 | 0.694 |

**Table 4: Langmuir isotherm constants and correlation coefficient for total aerobic sorption.**

| | Surface water (Industrial area) | | | Surface water (Residential area) | | |
|---|---|---|---|---|---|---|
| | $R^2$ | $Q_m$ | $K_L$ | $R^2$ | $Q_m$ | $K_L$ |
| **Horn char** | 1 | 2.5E5 | 1.1E6 | 0.9980 | 3.3E5 | 9.2E5 |
| **Bone char** | 0.9978 | 2.5E5 | 8.5E5 | 0.9972 | 3.3E5 | 1.2E6 |
| **Aluminium modified horn char** | 0.9997 | 2.5E5 | 4.4E5 | 0.9961 | 3.3E5 | 1.3E6 |
| **Aluminium modified bone char** | 0.9998 | 2.5E5 | 6.1E5 | 0.9958 | 3.3E5 | 1.1E6 |
| **Zinc modified horn char** | 0.9963 | 2.5E5 | 2.8E5 | 0.9960 | 3.3E5 | 3.3E5 |
| **Zinc modified bone char** | 0.9961 | 2.5E5 | 2.4E5 | 0.9961 | 3.3E5 | 5.1E5 |

**Table 5: Langmuir isotherm constants and correlation coefficient for coliform sorption.**

| | Surface water (Industrial area) | | | Surface water (Residential area) | | |
|---|---|---|---|---|---|---|
| | $R^2$ | $Q_m$ | $K_L$ | $R^2$ | $Q_m$ | $K_L$ |
| **Horn char** | 0.9973 | 3.3E4 | 7.50E4 | 0.9992 | 3.3E3 | 7.7E3 |
| **Bone char** | 0.9969 | 3.3E4 | 9.96E4 | 0.9977 | 2.5E3 | 9.9E3 |
| **Aluminium modified horn char** | 0.9962 | 3.3E4 | 6.01E4 | 0.9966 | 3.3E3 | 5.9E3 |
| **Aluminium modified bone char** | 0.996 | 3.3E4 | 3.53E4 | 0.9981 | 3.3E3 | 6.5E3 |
| **Zinc modified horn char** | 0.9962 | 3.3E4 | 9.96E4 | 0.9965 | 3.3E3 | 2.1E3 |
| **Zinc modified bone char** | 0.9962 | 3.3E4 | 6.80E4 | 0.9976 | 3.3E3 | 7.0E3 |

**Table 6: Langmuir isotherm constants and correlation coefficient for total fungal sorption.**

| | Surface water (Industrial area) | | | Surface water (Residential area) | | |
|---|---|---|---|---|---|---|
| | $R^2$ | $Q_m$ | $K_L$ | $R^2$ | $Q_m$ | $K_L$ |
| **Horn char** | 0.9854 | 2.0E6 | 5.84E6 | 0.9985 | 5.0E4 | 1.1E5 |
| **Bone char** | 0.9854 | 2.0E6 | 7.46E6 | 0.9986 | 5.0E4 | 8.9E4 |
| **Aluminium modified horn char** | 0.9948 | 2.0E6 | 4.34E5 | 0.9966 | 5.0E4 | 1.1E4 |
| **Aluminium modified bone char** | 0.9807 | 2.0E6 | 4.43E5 | 0.9967 | 5.0E4 | 2.0E4 |
| **Zinc modified horn char** | 0.9962 | 2.0E6 | 5.35E5 | 0.9972 | 5.0E4 | 2.0E4 |
| **Zinc modified bone char** | 0.9960 | 2.0E6 | 4.72E5 | 0.9965 | 5.0E4 | 1.6E4 |

The value of the dimensionless equilibrium parameter expressing Langmuir isotherm ($R_L$) between zero and unity signifies favourable sorption (Moreno *et. al.,* 2010). Biosorbents $R_L$ values calculated from the respective initial pathogen concentration ($C_o$) and Langmuir parameter ($K_L$) in Tables 4-6 range between $4.87 \times 10^{-18} – 1.76 \times 10^{-14}$. These indicate favourable adsorption processes of total aerobic, coliform and total fungal at $C_o$ of $2.75 \times 10^7$, $3.35 \times 10^6$ and $7.6 \times 10^7$ cfu/mL respectively. This is in agreement with the computed values presented in Lin *et. al.,* (2010) study. The values of n for polluted surface water in residential area were less than unity (Tables 1-3). These indicate significant pathogen adsorption in the column experiment at elevated concentration. Nonetheless, the increase in the amount adsorbed at higher concentration is noteworthy.

### *5.3 Pseudo Kinetic Sorption*

Correlation coefficients for first-order pseudo kinetic model were less than 0.82 due to non - linearity between $Log(Q_e - Q_t)$ and $t$ over the time range. There was considerable disparity between the values of experimental $LogQ_e$ (intercept) obtained from the plot of $Log(Q_e - Q_t)$ against $t$ and calculated $LogQ_e$. Most values of the latter were approximately twice as much as the former denoted with $I_q$ (Tables 7 & 8). According to Dhodapkar *et. al.,* (2009), these indicate that the adsorption of microbial parameters does not follow first-order kinetic. However, pseudo-second order was applicable, with good relationship between $t/Q_t$ and $t$ for all biosorbents ($R^2 > 0.98$). This implies that more than a particular mechanism is involved in the adsorption of microbial parameter. Calculated $Q_t$ and experimental $Q_e$ computed from the plot of $t/Q_t$ against $t$ were closely related (Tables 9 & 10). Furthermore, high values of adsorption capacity are indicative of strong attractive force between the adsorbate and adsorbent binding surface (Dhodapkar *et. al.,* 2009). The result confirms the applicability of pseudo second-order model in microbial sorption and suggests the involvement of chemisorptions process. Results obtained are in agreement with most adsorption kinetic rate studies (Esmaeili *et. al.,* 2008; Pan, *et. al.,* 2009; Dizadji *et. al.,* 2011).

**Table 7: Pseudo-first-order kinetic parameters for microbial sorption in polluted surface water from industrial area**

| | Total Aerobic | | | Coliform | | | Total Fungal | | |
|---|---|---|---|---|---|---|---|---|---|
| | $R^2$ | $LogQ_e$ | $I_q$ | $R^2$ | $LogQ_e$ | $I_q$ | $R^2$ | $LogQ_e$ | $I_q$ |
| **HC** | 0.7481 | 5.480 | 2.6136 | 0.7821 | 4.591 | 2.4548 | 0.7767 | 5.966 | 2.9225 |
| **BC** | 0.7934 | 5.448 | 2.7496 | 0.7894 | 4.572 | 2.4606 | 0.7758 | 5.968 | 2.9163 |
| **AHC** | 0.7665 | 5.512 | 2.7165 | 0.7821 | 4.606 | 2.4725 | 0.7765 | 5.988 | 2.9370 |
| **ABC** | 0.7685 | 5.488 | 2.6936 | 0.7816 | 4.618 | 2.4785 | 0.7764 | 5.988 | 2.9364 |
| **ZHC** | 0.7778 | 5.531 | 2.7801 | 0.7817 | 4.519 | 2.4666 | 0.7765 | 5.987 | 2.9369 |
| **ZBC** | 0.7791 | 5.532 | 2.7840 | 0.7877 | 4.596 | 2.4760 | 0.7765 | 5.988 | 2.9370 |

**Table 8: Pseudo-first-order kinetic parameters for microbial sorption in polluted surface water from residential area**

| | Total Aerobic | | | Coliform | | | Total Fungal | | |
|---|---|---|---|---|---|---|---|---|---|
| | $R^2$ | $LogQ_e$ | $I_q$ | $R^2$ | $LogQ_e$ | $I_q$ | $R^2$ | $LogQ_e$ | $I_q$ |
| **HC** | 0.7797 | 5.683 | 2.8099 | 0.7716 | 4.772 | 2.5190 | 0.7955 | 3.516 | 2.0685 |
| **BC** | 0.7858 | 5.666 | 2.8219 | 0.7683 | 4.777 | 2.5151 | 0.7964 | 3.507 | 2.0893 |
| **AHC** | 0.7866 | 5.681 | 2.8466 | 0.8129 | 4.821 | 2.5906 | 0.7875 | 3.570 | 2.1231 |
| **ABC** | 0.7911 | 5.689 | 2.8623 | 0.8026 | 4.818 | 2.5661 | 0.7889 | 3.555 | 2.1051 |
| **ZHC** | 0.7793 | 5.731 | 2.8529 | 0.7813 | 4.817 | 2.5441 | 0.7865 | 3.590 | 2.1333 |
| **ZBC** | 0.7837 | 5.718 | 2.8540 | 0.7812 | 4.819 | 2.5468 | 0.8151 | 3.528 | 2.1372 |

**Table 9: Pseudo-second-order kinetic parameters for microbial sorption in polluted surface water from industrial area**

| | Total Aerobic | | | Coliform | | | Total Fungal | | |
|---|---|---|---|---|---|---|---|---|---|
| | $R^2$ | $Q_e(\times10^6)$ | $Q_t(\times10^6)$ | $R^2$ | $Q_e(\times10^6)$ | $Q_t(\times10^6)$ | $R^2$ | $Q_e(\times10^6)$ | $Q_t(\times10^6)$ |
| HC | 0.9940 | 200 | 180 | 0.9899 | 25 | 22.0 | 0.9883 | 500 | 439 |
| BC | 0.9891 | 200 | 180 | 0.9877 | 25 | 22.0 | 0.9891 | 500 | 439 |
| AHC | 0.9978 | 200 | 180 | 0.9877 | 25 | 22.0 | 0.9869 | 500 | 439 |
| ABC | 0.9979 | 200 | 180 | 0.9873 | 25 | 22.0 | 0.9871 | 500 | 439 |
| ZHC | 0.9879 | 200 | 171 | 0.9878 | 25 | 20.7 | 0.9869 | 500 | 439 |
| ZBC | 0.9870 | 200 | 171 | 0.9862 | 25 | 22.0 | 0.9869 | 500 | 439 |

**Table 10: Pseudo-second-order kinetic parameters for microbial sorption in polluted surface water from residential area**

| | Total Aerobic | | | Coliform | | | Total Fungal | | |
|---|---|---|---|---|---|---|---|---|---|
| | $R^2$ | $Q_e(\times10^6)$ | $Q_t(\times10^6)$ | $R^2$ | $Q_e(\times10^6)$ | $Q_t(\times10^6)$ | $R^2$ | $Q_e(\times10^6)$ | $Q_t(\times10^6)$ |
| HC | 0.9911 | 333 | 281.3 | 0.9933 | 2.5 | 2.20 | 0.9923 | 33.3 | 30.5 |
| BC | 0.9884 | 333 | 281.3 | 0.9903 | 2.5 | 1.80 | 0.9905 | 33.3 | 30.5 |
| AHC | 0.9846 | 333 | 281.3 | 0.9885 | 2.5 | 1.71 | 0.9868 | 33.3 | 28.1 |
| ABC | 0.9826 | 333 | 281.3 | 0.9905 | 2.5 | 2.20 | 0.9876 | 33.3 | 28.1 |
| ZHC | 0.9865 | 333 | 281.3 | 0.9878 | 2.5 | 2.07 | 0.9873 | 33.3 | 28.1 |
| ZBC | 0.9853 | 333 | 281.3 | 0.9857 | 2.5 | 2.20 | 0.9870 | 33.3 | 28.1 |

## 6.0 CONCLUSION

The sorption of microbial parameters on biosorbents from cattle bone and horn followed pseudo-second order kinetic model ($R^2 > 0.98$). The adsorption processes were well described by Freundlich and Langmuir isotherm models irrespective of water source and adsorbent type ($R^2 > 0.98$). The biosorbents from abattoir biodegradable solid wastes have high adsorption capacities for total aerobic, coliform and total fungal sorption. Bone and horn chars are effective biosorbents for pathogen diminution in polluted waters in addition to their low-cost and environment-friendly benefits.

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