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(RESEARCH ARTICLE)

Effect of biochar type on planting media with different weight metal containments of Pb, Cd, and CR on growth, results, and quality of corn (*Zea mays L.*) results

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Abstract

Utilizing the Badung River, which contains heavy metals, as agricultural irrigation poses risks to crop yields and human health due to metal absorption by plants. Biochar has potential for remediating such contaminants. This study aimed to assess the impact of different concentrations of heavy metals (Pb, Cd, and Cr) in planting media and determine the most effective biochar type for enhancing corn growth, yield, and quality. A randomized group design was used with two factors: heavy metal concentrations (0 ppm, 500 ppm, 1000 ppm) and biochar types (rice straw and husk, coconut shell and husk, vegetable and fruit waste), totaling nine treatment combinations and 27 experimental units. The soil used was contaminated soil from the lower Badung River. Results showed that the highest heavy metal concentration negatively affected growth parameters, including number of leaves (21.22), chlorophyll content (29.58), relative water content (0.90%), root length (192.10 px), surface area (323.75 px^2), tissue area (126.36 px^2), and 1000-seed weight (169.24 g). Among biochar types, rice straw and husk significantly improved root oven dry weight (1.23 g), seed weight at 14% moisture (1.51 g), and plant height (224.11 cm). An interaction was observed between heavy metal levels and biochar types on leaf chlorophyll, cob length, and root fresh weight. Further studies are recommended to explore additional heavy metals and alternative biochar sources for broader remediation applications.

Keywords: Biochar; Cadmium; Chromium; Heavy Metal; Lead; Maize

1. Introduction

The Badung River, which flows along Denpasar City, has many benefits for both the community and the surrounding environment. However, along with the growth of the population that uses this river for household, agricultural, and industrial activities, the higher the pollution that occurs in the Badung River. One of the sectors that is affected by heavy metal pollution is the agricultural sector, there are several subak in Denpasar City through which the river is indicated to be contaminated by heavy metals lead (Pb), cadmium (Cd), and chromium (Cr). Maize (Zea mays L.) is one of the most important food crops in Indonesia after rice. Maize is widely chosen as a research subject because this plant is very responsive to changes in environmental conditions, especially in the soil. Maize plants get their irrigation water source from a dam that comes from the downstream of the Badung River. The condition of the downstream Badung River, which is polluted and indicated to contain heavy metals if used as a means of irrigation, will certainly affect the quality of agricultural products which in turn can have an adverse impact on public health if consumed intensively. This research proposes one way to restore the condition of the soil contaminated with heavy metals by remediating the soil using biochar from various types of agricultural waste such as rice husk and straw biochar, coconut husk and shell biochar, and fruit and vegetable waste biochar. The use of biochar in reducing the impact of heavy metal pollution is expected to improve soil quality and the growth and quality of corn crops.

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2. Materials and Methods

The research materials used were soil samples, irrigation water samples, corn samples, heavy metals Pb, Cd, Cr, distilled water, corn seeds, rice straw and husk waste, shell and coconut husk waste, vegetable and fruit waste, firewood, kerosene, water, and fertilizer.

The research tools used are polybags, shovels, scissors, knives, gloves, plastic, sacks, tarpaulins, blenders, filters, trays, drums, scales, labels, rulers, stationery, munsell plant tissue color charts, SPAD chlorophyll meters, lux meters, SEM test equipment (Scanning Electron Microscope), and proximate test equipment (ASTM D7582 MVA).

The research took place from May to October 2024. Soil, irrigation water, and corn samples were collected at Subak Kerdung in Pedungan Village, Subak Sesetan in Sesetan Village, Subak Kepaon and Subak Cuculan in Pemogan Village, and Subak Margaya in Pemecutan Village. The research was conducted in the greenhouse of the Experimental Garden of the Faculty of Agriculture, Udayana University. Analysis of biochar characteristics was carried out at Mero Foundation Tulamben Karangasem. Analysis of heavy metals in soil before the study was carried out at MSU Russia, and analysis of heavy metals and plant organs after the study was carried out at the Analytical Laboratory of Udayana University. This study used a two-factor group randomized design with nine treatment combinations repeated three times. The first factor was the planting media from five subaks contaminated with heavy metals in the lower Badung River. The second factor was the type of biochar derived from rice straw and husk, coconut shell and coir, and vegetable and fruit waste. Variables observed included plant growth, yield and quality, and soil quality before and after treatment.

2.1. Sample Collection

Soil samples were taken randomly by purposive sampling method from paddy fields in subak-subak that get irrigation from the Badung River downstream, namely Subak Kerdung in Pedungan Village, Subak Sesetan in Sesetan Village, Subak Kepaon and Subak Cuculan in Pemogan Village, and Subak Margaya in Pemecutan Village. Five soil samples from five different subak were composited and then analyzed at the Integrated Laboratory of Udayana University. Analysis of soil samples in the laboratory was carried out for heavy heavy metal variables Pb, Cd, and Cr.

2.2. Preparation of Planting Media

Polybags with a diameter of 40 x 40 cm as many as 27 pieces were filled with planting media of heavy metal contaminated soil from subak samples in the lower Badung River (Ms) that had been sieved and aerated and biochar according to the treatment level of biochar types with different raw materials. Polybags with a diameter of 40 x 40 cm were filled with planting media with a composition of soil and biochar ratio of 7 kg of soil mixed with 52.5 g biochar (w/w) (recommended use of biochar for corn is 15 tons/ha), then given a code according to the combination of soil planting media treatment with different heavy metal content and biochar types with different raw materials.

Heavy metal injection in Mf and Mh was carried out by taking 1 kg of 7 kg of air-dried soil planting medium that was originally used per polybag. The 1 kg of soil was injected with heavy metals according to the level of Mf and Mh, then mixed with 6 kg of soil that was not injected evenly, then mixed again with biochar according to the treatment level.

2.3. Biochar Making

Biochar from different raw materials is made according to the method of Wedayani et al. (2024), namely with several stages, starting with raw materials that are cut into small pieces and then dried by drying in the sun until completely dry. After that, biochar making is continued by pyrolyzing at 400°C. Initial pyrolysis was carried out in the laboratory using a furnace to determine the temperature and time required for the raw materials to be pyrolyzed into charcoal or activated carbon. After knowing the required combustion time, the pyrolysis process was then carried out manually using the pyrolysis method in stages. The charcoal produced from the pyrolysis process is then activated using CaCl2 solution so that it becomes biochar. The ready biochar was then analyzed using Scanning Electron Microscope (SEM) test to determine its physico-chemical characteristics, as well as proximate test to determine the content of water content, ash content, volatile content and carbon content in biochar. SEM tests were carried out on each type of biochar using a voltage of 5.0 kV, an average working distance of 10.5 mm, a current probe of 30 and varying magnification at MERO Foundation. Proximate tests were conducted using ASTM D7582 MVA at the Engineering Laboratory, Faculty of Engineering, Udayana University.

2.4. Maize Planting

Polybags with 7 kg of soil as many as 27 pieces were filled with planting media that had been injected with heavy metals and given biochar and then planted with 3 corn seeds per polybag. Seed soaking was carried out the day before planting

using tap water for 10 hours, then removed and aerated. Maize plants were intensively maintained including fertilization, watering, soil loosening, pest and disease control to ensure optimal maize growth and yield. Fertilization is done according to the recommendations for fertilizing corn plants. The recommended fertilizer dose for maize is a single fertilizer dose package of Urea, SP-36 and KCl at a dose of 375 kg Urea/ha, 125 kg SP-36/ha, and 125 kg KCL/ha respectively, or a dose package of NPK 15-15-15 compound fertilizer and Urea at a dose of 350 kg 15-15-15 compound fertilizer/ha and 250 kg urea/ha respectively (Deptan, 2023). In this study, considering that it was easier to obtain fertilizer, the type and dose of NPK fertilizer used was in the form of Phonska Plus 15-15-15 at a dose of 350 kg/ha and Urea at a dose of 250 kg/ha. Harvesting was done when the corn kernels were physiologically ripe, marked by the drying of the cob and the color changing from green to brown.

2.5. Observation Variable

2.5.1. Fresh weight of stover (g)

Fresh weight of stover was measured when the corn plants were harvested. This observation is made by weighing the stalks of corn plants such as leaves, stems, and male flowers with analytical scales when they have just been uprooted but have been cleaned of any dirt such as soil, sand, etc.

2.5.2. Oven dry weight of stover (g)

Oven dry weight of stover was weighed when the maize plants had been harvested by drying the stover in the sun, then the stover was wrapped in paper and oven dried at 700°C until the weight was constant, then the stover was weighed with an analytical balance.

2.5.3. Seed weight per plant (g)

Seed weight per plant was measured using an analytical balance and done after harvest.

2.5.4. Seed weight 14% water content (g)

The weight of seeds with 14% moisture content was weighed using a weighing scale after the seeds were dried in the sun and measured with a Grain Moisture Meter until it touched a minimum of 14%.

2.5.5. Heavy metal content of Pb, Cd, and Cr in soil, irrigation water, and corn plant organs before the study

Soil samples taken from subak fields were air dried and labeled. Irrigation water samples were taken from 3 locations along the lower Badung River and composited into 3 bottles. Plant organ samples from the subak were separated into roots, stems, and seeds, then dried and pulverized into fine granules. Each sample of roots, stems, and seeds was labeled. Then all samples were analyzed in the laboratory.

2.5.6. Heavy metal content of Pb, Cd, and Cr in soil after the study

Soil samples in each polybag were taken and then the content of heavy metals Pb, Cd, and Cr were analyzed in the laboratory. Soil samples were air-dried, then pulverized to a fine grain. Samples that have been finely weighed as much as 0.45-0.55 grams and then put into a vessel that has been rinsed with concentrated HNO3: distilled water (2: 1), then dried in an oven at 105 ºC (done 10x), then concentrated HNO3 is added to the vessel as much as 10 mL. The vessel was closed and placed on the rotor in sequence. Samples were deconstructed using Anton Paar Microwave (approximately 45 minutes). The results of the deconstruction were put into a 50 mL volumetric flask, then added internal standard (ISTD) 10 mg/L as much as 0.4 mL then flushed with distilled water and homogenized. The sample solution was filtered with a filter equipped with a 0.20 µm RC/GHP filter, after which the sample solution was put into the tube. The filtered sample solution was then measured for heavy metals Pb, Cd, and Cr using an Inductively Coupled Plasma-Mass Spectrometer (ICP-MS). Analysis of heavy metal samples (Pb, Cd, Cu, Cr, and Hg) using Atom-Flame AA300 absorption spectrophotometry (Analytic Jena AG, 2014) at each wavelength, namely Pb at a wavelength of 217.0005 nm, Cd at 228.8018 nm, and Cr at 357.869 nm.

2.5.7. Heavy metal content of Pb, Cd, and Cr in roots, stems, and seeds

At harvest time, plant organ samples were separated into roots, stems, and seeds and then dried and pulverized to a fine granular form. Each root, stem, leaf, and seed sample was labeled. Samples that have been finely weighed as much as 0.45-0.55 g and then put into a vessel that has been rinsed with concentrated HNO3: distilled water (2: 1), then dried in an oven at 105 ºC (done as much as 10x), then concentrated HNO3 is added to the vessel as much as 10 mL. The vessel was closed and placed on the rotor sequentially. The sample was deconstructed using Anton Paar Microwave

(approximately 45 minutes). The results of the deconstruction were put into a 50 mL flask, then added internal standard (ISTD) 10 mg/L as much as 0.4 mL then flushed with distilled water and homogenized. The sample solution was filtered with a filter equipped with a 0.20 µm RC/GHP filter, after which the sample solution was put into the tube. The filtered sample solution was then measured for heavy metals Pb, Cd, and Cr using an Inductively Coupled Plasma-Mass Spectrometer (ICP-MS). Analysis of heavy metal samples (Pb, Cd, and Cr) using Atom-Flame AA300 absorption spectrophotometry (Analytic Jena AG, 2014) at each wavelength, namely Pb at a wavelength of 217.0005 nm, Cd at 228.8018 nm, and Cr at 357.869 nm.

2.5.8. Bioaccumulation factors (BAF) of maize plants for heavy metals Pb, Cd, and Cr

To determine the ability of plants to accumulate heavy metals contained in the soil can be calculated based on the concentration ratio between metals in plants and heavy metal concentrations in the soil, which can be calculated by the formula:

$$BAF = \frac{Heavy\ metal\ concentration\ in\ plants}{Heavy\ metal\ concentration\ in\ soil}$$

2.5.9. Translocation factor (TF) of maize plants to heavy metals Pb, Cd, and Cr

To determine the ability of plants to transfer heavy metals from the roots to the shoots can be calculated based on the formula from Gupta (2013), namely:

$$TF = \frac{Heavy\ metal\ concentration\ in\ shoots}{Heavy\ metal\ concentration\ in\ roots}$$

3. Results and Discussion

3.1. Results of Heavy Metal Analysis in Soil Before the Study

Based on the analysis in the analytical laboratory, it was found that the highest heavy metal content in the soil was heavy metal Pb (75.43 mg/kg), and the lowest heavy metal content in the soil was heavy metal Cr (5.73 mg/kg) (Figure 1)

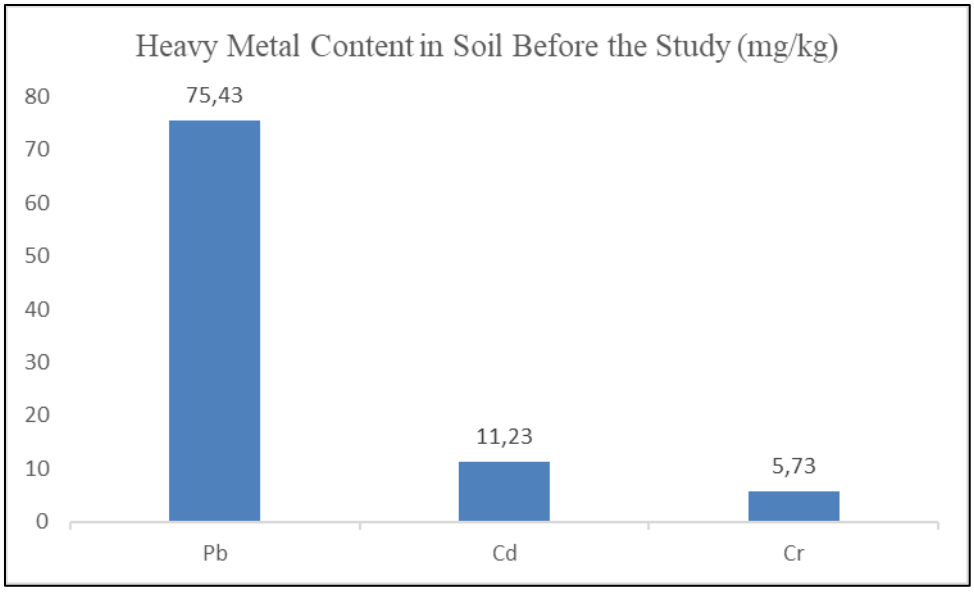


Figure 1 Graph of Heavy Metals in Soil Before the Study

3.2. Results of Heavy Metal Analysis in Irrigation Water Before the Study

Based on analysis in the analytical laboratory, it was found that the highest heavy metal content in irrigation water was heavy metal Pb in sample III (0.31 mg/L), and the lowest heavy metal content in irrigation water was heavy metal Cd in sample II (0.01 mg/L) (Table 1).

Table 1 Results of heavy metal analysis in irrigation water before the study

Sample Code	I (mg/L)	II (mg/L)	III (mg/L)	Total	Average
Pb	0.18	0.13	0.31	0.62	0.21
Cd	0.02	0.01	0.03	0.06	0.02
Cr	0.03	0.03	0.06	0.12	0.04

Source: Analysis Results at UNUD Analytical Laboratory, 2024

3.3. Results of Heavy Metal Analysis of Pb, Cd, and Cr in Total Soil After Biochar Treatment

Based on Table 2, the highest total soil heavy metal content is Pb in rice husk and straw biochar (Br) at (9.70 mg/kg), and the lowest total soil heavy metal content is Cd in coconut husk and shell biochar (Bc) at 0.21 mg/kg.

Table 2 Heavy metals Pb, Cd, and Cr in total soil after biochar treatment

Biochar	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Total	Average
Br	9.70	0.24	5.11	15.05	5.02
Bc	9.38	0.21	5.34	15.10	5.03
Bw	8.44	0.37	5.42	13.94	4.65

Source: Analysis Results at MSU Rusia, 2024

3.4. Results of Heavy Metal Analysis of Pb, Cd, and Cr in Available Soil After Biochar Treatment

Based on Table 3, the highest available soil heavy metal content is Pb in biochar rice husk and straw (Br) of 0.435 mg/kg, and the lowest available soil heavy metal content is Cd in biochar coconut husk and shell (Bc) of 0.095 mg/kg.

Table 3 Heavy metals Pb, Cd, and Cr in soil available after biochar treatment

Biochar	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Total	Average
Br	0.435	0.206	0.099	0.634	0.211
Bc	0.404	0.095	0.114	0.615	0.205
Bw	0.323	0.105	0.111	0.640	0.213

Source: Analysis Results at MSU Rusia, 2024

3.5. Results of Heavy Metal Analysis of Pb, Cd, and Cr in Corn Plant Organs After Biochar Treatment

3.5.1. Results of Heavy Metal Analysis of Pb, Cd, and Cr in Corn Roots After Biochar Treatment

Based on Table 4, the highest heavy metal content in the roots was heavy metal Pb without additional injection (Ms) in the coir and coconut shell biochar treatment (Bc) of 22.77 mg/kg. On the other hand, fruit and vegetable waste biochar in the treatment without additional injection (Ms), 500 ppm (Mf), and 1000 ppm (Mh) did not detect the content of heavy metals Pb and Cd.

Table 4 Heavy metals Pb, Cd, and Cr in corn roots after biochar treatment

Treatments	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)
MsBr	9.73	0.95	2.04
MsBc	22.77	1.89	4.68
MsBw	nd	nd	1.61
Mfbr	2.19	0.23	2.48
MfBc	nd	nd	nd
MfBw	nd	nd	0.97
MhBr	nd	nd	0.90
MhBc	3.11	0.32	2.59
MhBw	nd	nd	0.97

Source: Analysis Results at UNUD Analytical Laboratory, 2024; Description: nd = not detected

3.5.2. Results of Heavy Metal Analysis of Pb, Cd, and Cr in Corn Stover After Biochar Treatment

Based on Table 5, the highest heavy metal content in the stover was the uninjected heavy metal Cr (Ms) in the biochar treatment of rice husk and straw (Br) at 1.89 mg/kg, while the heavy metal content of Pb and Cd was not available in the stover.

Table 5 Heavy metals Pb, Cd, and Cr in corn stover after biochar treatment

Treatments	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)
MsBr	nd	0.005	1.89
MsBc	nd	nd	0.58
MsBw	nd	nd	1.29
Mfbr	nd	nd	0.37
MfBc	nd	nd	0.67
MfBw	nd	nd	0.32
MhBr	nd	nd	0.25
MhBc	nd	nd	1.76
MhBw	nd	nd	0.42

Source: Analysis Results at UNUD Analytical Laboratory, 2024; Description: nd = not detected

3.5.3. Results of Heavy Metal Analysis of Pb, Cd, and Cr in Maize Seeds After Biochar Treatment

Based on Table 6, the highest heavy metal content in seeds is heavy metal Cr with a concentration of 1000 ppm in the coir and coconut shell biochar treatment (MhBc) of 0.96 mg/kg, while the content of heavy metals Pb and Cd is not available in seeds.

Table 6 Heavy metals Pb, Cd, and Cr in corn kernels after biochar treatment

Treatments	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)
MsBr	nd	nd	0.39
MsBc	nd	nd	0.70
MsBw	nd	nd	nd
Mfbr	nd	nd	nd
MfBc	nd	nd	0.34
MfBw	nd	nd	0.20
MhBr	nd	nd	0.31
MhBc	nd	nd	0.96
MhBw	nd	nd	nd

Source: Analysis Results at UNUD Analytical Laboratory, 2024; Description: nd = not detected

3.6. Fresh Weight of Stem

Fresh weight of stems showed no significant response to the single treatment of planting media with heavy metal content. Based on Table 7 below, the highest average fresh weight of fresh fruit was found in the Ms treatment (348.44 g), and the lowest average fresh weight of fresh fruit was found in the Mf treatment (342.11 g).

Fresh weight of stalks showed a response of no significant effect on a single treatment of biochar type. The highest average fresh weight of fresh fruit was found in the Bw treatment (345.00 g), and the lowest average fresh weight of fresh fruit was found in the Bc treatment (343.67 g).

Table 7 Effect of heavy metal content and biochar type on variables of fresh weight of stover, oven dry weight of stover, and number of seeds per plant

Treatments	Fresh Weight of Stem (g)	Oven Dry Weight Stem (g)
Ms	348.44 a	0.31 (0.90) a
Mf	342.11 a	0.27 (0.88) a
Mh	342.67 a	0.29 (0.89) a
BNT 5%	23.97	0.04
Br	344.56 a	0.29 (0.89) a
Bc	343.67 a	0.31 (0.90) a
Bw	345.00 a	0.27 (0.88) a
BNT 5%	23.97	0.04

Description: Numbers followed by the same letter in the same treatment and column in the same treatment and column show no significant difference in the 5% BNT test.

3.7. Oven Dry Weight Stem

The oven dry weight of stover showed an unrealistic response to the single treatment of planting media with heavy metal content. Based on Table 7 above, the highest average dry weight of oven bran was found in the Ms treatment (0.31 g), and the lowest average dry weight of oven bran was found in the Mf treatment (0.27 g).

The oven dry weight of stover showed no significant response to a single treatment of biochar type. The highest average oven dry weight of stover was found in the Bc treatment (0.31 g), and the lowest average oven dry weight of stover was found in the Bw treatment (0.27 g).

3.8. Seed Weight per Plant

Seed weight per plant showed a response of no significant effect on the single treatment of planting media with heavy metal content. The highest average seed weight was found in the Mh treatment (29.74 g), and the lowest average seed weight was found in the Ms treatment (25.49 g).

Seed weight per plant showed an unrealistic response to the single treatment of biochar type. The highest average seed weight was found in the Bw treatment (36.69 g), and the lowest average seed weight was found in the Br treatment (36.43 g).

3.9. Seed Weight 14% Water Content

Seed weight of 14% water content showed an unrealistic response to the single treatment of planting media with heavy metal content. The highest average seed weight of 14% water content was found in the Mh treatment (1.91 g), and the lowest average seed weight of 14% water content was found in the Ms and Mf treatments (1.86 g).

Seed weight of 14% water content showed a very significant response to a single treatment of biochar type. The highest average seed weight of 14% water content was found in the Bw treatment (3.47 g), and the lowest average seed weight of 14% water content was found in the Br treatment (1.51 g).

3.10. Bioaccumulation Factor (BAF) and Translocation Factor (TF)

Based on Table 8, the samples taken in the field before the study had the highest bioaccumulation value obtained in heavy metal Cr (0.73), and the lowest bioaccumulation value obtained in heavy metal Cd (0.13). The highest translocation value was obtained by heavy metal Cr (0.47), while the translocation value for heavy metals Pb and Cd was not available because heavy metals Pb and Cd were not detected in the corn shoot samples.

Tabel 8 BAF and TF values of heavy metals in maize plants sampled from farmers' paddy fields

Heavy Metal Type	Concentrations in soil (mg/kg)	Concentration in plants (mg/kg)	Concentration in roots (mg/kg)	Concentration in shoots (mg/kg)	BAF Values	TF Values
Pb	75.43	15.08	15.08	0.00	0.20	0.00
Cd	11.23	1.43	1.43	0.00	0.13	0.00
Cr	5.73	4.16	2.82	1.34	0.73	0.47

The results presented in Table 9 show that biochar treatment has a major effect on bioaccumulation and translocation of heavy metals in corn plants. The highest bioaccumulation value on straw biochar and rice husk was obtained on heavy metal Cd (1.662), and the lowest bioaccumulation value on straw biochar and rice husk was obtained on heavy metal Pb (0.409). For the highest translocation value on straw biochar and rice husk was obtained on heavy metal Cr (0.592). The translocation value of heavy metal Pb was not available because the heavy metal was not detected in corn shoots with biochar treatment of rice husk and rice straw.

The highest bioaccumulation value in coir and coconut shell biochar was obtained for heavy metal Cd (3.287), and the lowest bioaccumulation value in coconut shell and coir biochar was obtained for heavy metal Cr (0.766). For the highest translocation value in biochar shell and coconut fiber was obtained in heavy metal Cr (0.689). Translocation values of heavy metals Pb and Cd were not available because these heavy metals were not detected in corn shoots treated with coconut husk and coconut shell biochar.

The highest bioaccumulation value on fruit and vegetable waste biochar was obtained on heavy metal Cr (0.355). The highest translocation value for fruit and vegetable waste biochar was obtained for heavy metal Cr (0.631). Bioaccumulation and translocation values of heavy metals Pb and Cd are not available because these heavy metals were not detected in plants treated with fruit and vegetable waste biochar.

Table 9 BAF and TF values of heavy metals in corn plants grown with different biochar treatments

Heavy Metal Type	Concentrations in soil (mg/kg)	Concentration in plants (mg/kg)	Concentration in roots (mg/kg)	Concentration in shoots (mg/kg)	BAF Values	TF Values
Biochar of rice straw and husk (Br)						
Pb	9.702	3.971	3.971	0.000	0.409	0.000
Cd	0.238	0.396	0.394	0.002	1.662	0.005
Cr	5.109	2.877	1.807	1.070	0.563	0.592
Biochar of coir and coconut shell (Bc)						
Pb	9.382	8.626	8.626	0.000	0.919	0.000
Cd	0.225	0.739	0.739	0.000	3.287	0.000
Cr	5.343	4.095	2.425	1.670	0.766	0.689
Biochar of fruit and vegetable waste (Bw)						
Pb	8.437	0.000	0.000	0.000	0.000	0.000
Cd	0.372	0.000	0.000	0.000	0.000	0.000
Cr	5.424	1.925	1.180	0.745	0.355	0.631

4. Conclusions

- Land in the downstream Badung River has been contaminated with heavy metals exceeding the allowed quality threshold. Cd heavy metal contamination on land in the lower Badung River exceeds the allowed quality threshold, while Pb and Cr heavy metal contamination on land in the lower Badung River is still below the allowed quality threshold.
- Differences in the content of heavy metals Pb, Cd, and Cr in the planting media affect the growth, yield and quality of corn yield. The higher the content of heavy metals Pb, Cd, and Cr in the planting media, the lower the growth, yield, and quality of corn yield. The application of heavy metal concentration of 1000 ppm is the highest concentration that produces the lowest value in the variable number of leaves (21.22 strands), leaf chlorophyll (29.58), leaf KAR (0.90%), root length (192.10 px), root surface area (323.75 px^2), root tissue area (126.36 px^2), and 1000 seed weight (169.24 g).
- Different types of biochar with different raw materials affect the growth, yield, and quality of corn yield. Types of biochar with raw materials of rice husk and straw provide the best growth, yield, and quality of corn yield. Biochar of rice husk and straw gave a significant effect on the plant height variable (224.11 cm). In addition, rice straw and husk biochar gave a very significant effect on the variable of root oven dry weight (1.23 g) and seed weight at 14% water content (1.51 g).
- There was an interaction between the different content of heavy metals Pb, Cd, and Cr in the planting media and the type of biochar with different raw materials on the growth, yield, and quality of corn yield. Their interaction was shown in the variable of cob length MhBc (12.67 cm), leaf chlorophyll MhBc (35.85), and root fresh weight MsBw (131.67 g).

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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