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The Effects of Lead and Cadmium Chloride Poisoning in Haemoglobin

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ABSTRACT

On Earth, metallic elements naturally occur and are used in occupational, industrial and environmental areas. Heavy metal is a metal that has a high level of toxicity that can affect human health. Metal toxicity can be exposed to humans through chemical processes, physical processes, food chains, water and soil. Cadmium chloride and lead were used in this research. These two materials have been used widely in daily life. This research mainly studies the effect of lead and cadmium chloride contamination on blood. The aspect of pH is also explored in this research. The effects of lead and cadmium chloride on human blood are tested using a blood sample obtained from a haemoglobin bovine blood. Different amounts of lead and cadmium chloride are dissolved in the blood sample to compare the level of concentration of lead and cadmium in the blood. The morphology of the blood between different concentrations of lead cadmium is also observed. The blood morphology was obtained through FESEM and will be compared with normal blood. The blood sample absorbance was studied using UV-Vis and the pH value was measured. The blood morphology was changed when lead and cadmium chloride were added, affecting the blood's functionality. A higher amount of lead and cadmium chloride added lowers the blood concentration and gives low absorbance—the changes in pH value led to alkalosis and acidosis conditions.

1. Introduction

Metallic elements naturally occur in our earth, an intrinsic environmental component. This material is the main element in occupational, industrial and environmental circumstances. Two factors are involved in the distribution of metals in the environment: metal properties and environmental factors [1]. Metallic elements occur naturally in 92 elements and around 30 metals, which can harm humans. They are Be, B, Li, Al, Ti, V, Cr, Mn, Co, Ni, Cu, As, Se, Sr, Mo, Pd, Ag, Cd, Sn, Sb, Te, Cs, Ba, W, Pt, Au, Hg, Pb and Bi [2]. The toxicity of these elements has been acknowledged a long time ago. The lead effects of destruction were known before the second century in ancient Greece [3]. The toxicity of metal can be influenced by air-breathing, food and direct contact with the metallic element. The toxicity of metal may be harmful and can be exposed to humans through chemical, physical and microorganisms in air, food, water or soil [4].

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In this study, we are focusing on two elements: cadmium chloride and lead. These two materials are some examples of toxic metals in the surroundings. The metal toxicity depends on the quantity. When there is too much exposure, it becomes more toxic to human health. The chemical reactivity of the toxicity metal ions with the human system can be harmful to the human system as poisoning already existed long ago [4]. The effects of toxic metal can be seen in organs with high concentrations of metal, which depend on the chemical's exposure and the metal's compound.

Elements can be classified as metals or non-metals based on their physical properties, conductivity, electricity and malleability. Metal is a chemical element that is a good conductor of heat and electricity. In the periodic table, at least 70 elements are identified as metal. These metals will exhibit different properties according to temperature, among other factors. We can use Tin and Sn as an example. It displays non-metallic characteristics in certain states and gives properties like metal under certain states. We can classify metal into two types: heavy metal and light metal. Light metal is usually Magnesium, Aluminium and Titanium. Heavy metals are known as metals with potential toxicity. Four common elements are always called heavy metals: Cadmium, Mercury, Lead and Bismuth. These four elements are usually used in everyday human activities. Toxic metal is dispersed in our environment as we use it daily. The effects of metal are exposed through inhalation, ingestion and air-breathing [5].

Humans can be poisoned by cadmium through different methods. It can be exposed through inhalation, ingestion and in the environment. Cadmium enters the atmosphere from anthropogenic industrialisation-related sources such as atmospheric deposition, waste disposal, incineration of water and wastewater application in agricultural lands [6]. Exposure to Lead and Cadmium can affect human health, as mentioned above. Cadmium exposure has a harmful effect on human health. Intoxication after long-term exposure affects the most crucial organ in our body, which is the kidney. One of the symptoms is an increase in urinary excretion of proteins. When the kidney fails to operate accordingly, the proteinuria problem arises. This problem occurs when there are abnormal quantities of protein in the urine.

Cadmium affects several organs, such as the liver, bones, lungs, placenta, brain and central nervous system [7]. Exposure to lead can have a few effects on human health. The main effects are in the organ system, which is a haematological system, renal system and central nervous system. This includes mild mental retardation. Other effects of lead exposure are high blood pressure, gastrointestinal effects and anaemia. They also contribute to hypertension, decreased growth, immune system, nervous system and reproduction and development in the body. The effects of lead and cadmium on humans can be observed through the morphology of the blood sample that contains lead and cadmium. The effects will be based on blood lead concentration and cadmium levels [8].

To study the level of metal exposure that will affect the human blood by adding different amounts or concentrations of lead and cadmium to the blood sample, an extracted bovine blood is used to replace the human blood. In this research, the condition of the blood is maintained. It is essential to ensure the blood sample is prepared accordingly by dissolving it in distilled water. Different amounts of lead and cadmium chloride were added to the sample to study the level of exposure to lead and cadmium chloride. The other weight represents the concentration of lead and cadmium, which is to observe blood morphology after lead and cadmium chloride are added in different amounts [9].

The study of the effect of metal poisoning on human health is a significant endeavour to create a safe environment for the general and occupational populations according to the guidelines provided. This can be achieved by producing safe environment materials, using eco-friendly methods and using organic sources. This study is also beneficial to the occupational population group in creating awareness at their workplace to know their exposure limit during working hours and to educate people on the level of exposure or concentration of lead and cadmium that will affect their health.

Next, this study will help create awareness in the general population of the effects of heavy metals such as cadmium chloride and lead on their body so that they can take preventive measures to avoid higher levels of lead and cadmium contamination [10]. Moreover, the significance of this study is to educate the general and occupational population to take precautions against heavy metals to avoid the effects of poisoning metals on human health. The effects of lead and cadmium can lead to many severe diseases if no precaution is taken at the beginning.

2. Methodology

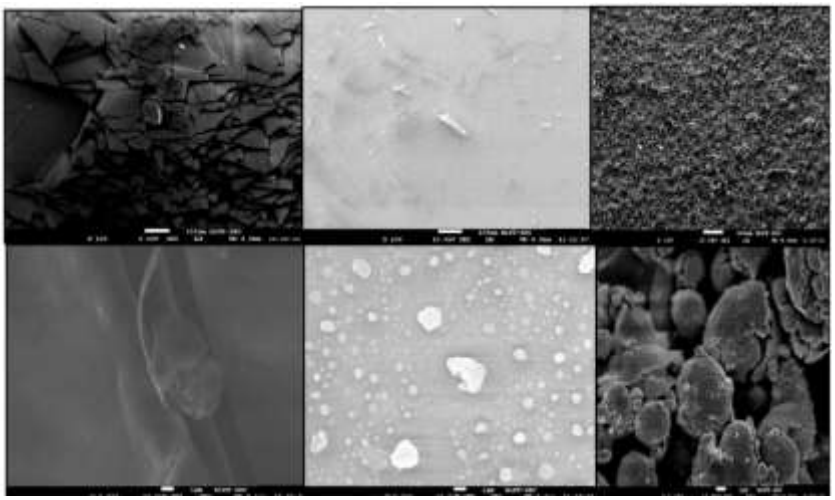
The blood sample was divided into nine parts in a test tube. Each test tube contains 4 ml of the blood sample solution. Four test tubes were for the cadmium chloride sample and four test tubes were for lead metal powder. A different amount of cadmium chloride was added to the blood sample for cadmium chloride. It was also for lead metal powder. Table 1 below shows the details of the samples.

Table 1
Sample descriptions

Samples	Descriptions
Blood	20 mg substrate powder, haemoglobin bovine blood powder and 1 ml distilled water
Cadmium chloride	2 g of cadmium chloride powder and 4 ml of distilled water
Lead powder	2 g Lead powder and 4ml of distilled water
Lead A	4 ml of blood solution and 2 g lead metal powder
Lead B	4 ml of blood solution and 4 g lead metal powder
Lead C	4 ml of blood solution and 6 g lead metal powder
Lead D	4 ml of blood solution and 8 g lead metal powder
Cadmium A	4 ml of blood solution and 2 g of cadmium chloride
Cadmium B	4 ml of blood solution and 4 g of cadmium chloride
Cadmium C	4 ml of blood solution and 6 g of cadmium chloride
Cadmium D	4 ml of blood solution and 8 g of cadmium chloride

3. Result and Discussion

The morphology study of all samples was obtained using FESEM instruments. Figure 1(a) shows the morphology of bovine haemoglobin at a magnification of 100x and 5000x with the sizes of 100µm and 1µm, respectively. The bovine haemoglobin morphology is not clearly shown as it demands modification to be clinically effective [24]. It does not show any shape of a biconcave disc as red blood cells in human blood should. This condition was probably because no interaction occurred between the powder and distilled water in the solution to form a biconcave disc. When lead powder and cadmium chloride were added, the interaction occurred. The original shape of the haemoglobin was also in substrate powder or a strip of haemoglobin. That explains the morphology of the blood, not in the biconcave disk. Thus, the result was obtained. The morphology of cadmium chloride is shown in Figure 1(b). The morphology of the cadmium chloride was observed to be lumpy in an area [11]. The particle sizes were observed to be different from each other. The morphology of the lead sample is shown in Figure 1(c). The solution was observed to be agglomerate and the sample images viewed grumbled as the sample was gathered in one place. It was also observed that the sample had a clotted image. The condition occurs due to the insolubility of the lead metal powder in the distilled water.



(a) (b) (c)

Fig. 1. Morphology at a magnification of 100x and 5000x for (a) Bovine haemoglobin (b) Cadmium chloride (c) Lead

Figure 2(a) shows the blood shape or the blood structure in the biconcave disk shape was visible. Even though the blood structure was visible, the clotted image of blood was shown. This condition occurs as the structure of lead itself [12]. When a lead was added to the blood sample, the blood structure was observed to be clotted around the lead. In the morphological image in Figure 2(b), the blood or blood structure in the biconcave disk shape was less visible than Lead A. The solution also seems to be more clotted. The blood structure was disrupted at this stage compared to Lead A. In the morphological image in Figure 2(c), the blood or blood structure in the biconcave disk shape was less visible than Lead B. There was an increase in the clotted area in the morphology of Lead Sample C. In this sample, the blood structure is disrupted and clotted more at the lead area.

In the morphological image in Figure 2(d), the blood or blood structure in biconcave disk shape was not visible compared to Lead A, B and C. There was an increase in the clotted area in the morphology of Lead Sample D. In this sample, the blood structure is being disrupted and clotted more at the lead area. The figure represents the morphology results of every sample using FESEM. The morphology was observed to check the functionality of the blood. The shape of the blood is in a biconcave, which has depth in the middle [13]. The shape of the blood makes it easier and faster to transport oxygen in the body. As the shape of blood is disturbed, the blood's functionality will also decrease and be ineffective. The shape of blood is an essential element as it represents the biological function and can also affect genetics [26]. The blood structure has a biconcave disk shape, which increases the blood volume and the oxygen carried and maintains high pressure.

When 2 g of Lead metal powder was added to the blood, the structure of the blood still can be seen. The red blood cell was clotted at a specific area, resulting from the interaction between the lead metal powder and the blood shape or morphology in the image, which was not in a biconcave disc shape. When the shape of the blood was disrupted, the oxygen level being transported by the blood was also low. This condition worsened as 4 g, 6 g, 8 g and 10 g of lead metal powder were added. When a function of the blood fails to perform, it leads to a low oxygen level in the body. A condition of blood with low oxygen is also called hypoxemia. Hypoxemia can cause hypoxia, a condition of low oxygen in tissue. These two conditions occur when blood does not transfer enough oxygen to fulfil the body's needs. When the body doesn't get enough oxygen, it also causes a low oxygen level to supply to other internal body parts [14].

When this condition occurs, it causes a low oxygen environment in anaerobic conditions, which stimulates the growth of pathogens such as viruses and bacteria and promotes the advancement of

the escalation of cancer cells. The study proves that the metal contamination of lead caused a severe problem in human health. The lack of oxygen is the first important cause of disease in humans [15].

The condition of the cell can also be differentiated into two conditions: hypotonic and hypertonic. The blood condition in Lead D is referred to as a hypotonic condition. It occurs when water enters and out of the cell and needs to be balanced. Too much water enters the solution, causing it to have less solute and more water than another solution. The condition of the cell in lead D is called turgid, where it can be seen that the blood cell is bloated or tumid compared to lead A. The lead toxicity also altered the plasma in the blood. This is because a normal blood morphology is maintained when a natural isotonic condition of the plasma. When a cell is in a hypotonic solution, it levels up the volume of water as it absorbs more water and eventually contributes to higher pressure in the cell—the condition of high pressure leads the protoplasm to expand and collapse against the cell wall [16].

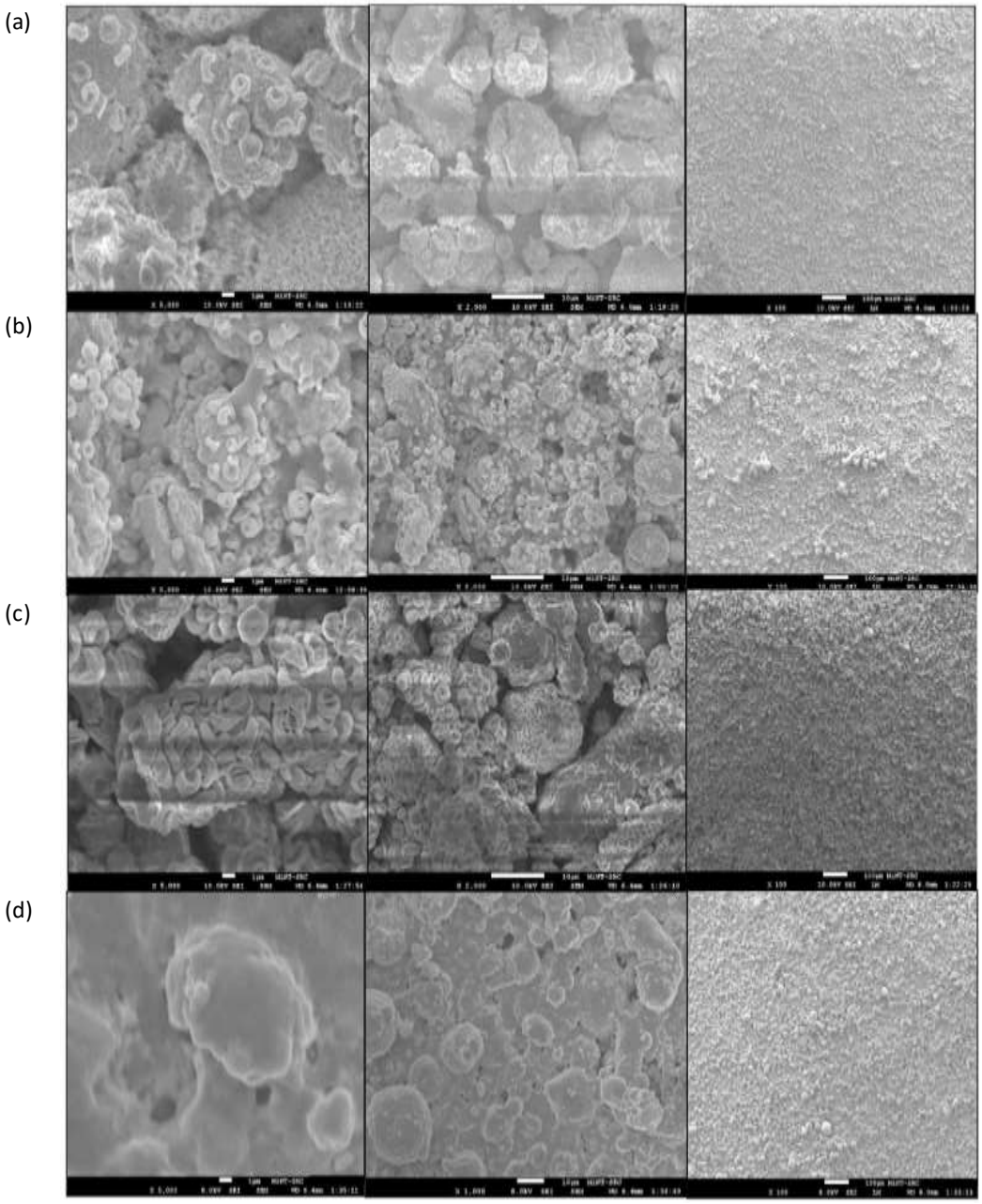


Fig. 2. Morphology of lead sample at a magnification of 5000x, 2 000x and 100x (a) A (b) B (c) C (d) D

In the morphological image in Figure 3, the blood shape was not visible as it has an element of chloride in the sample. The sample's condition can be compared through the clotting changes between the samples. The clotted area was visible at a certain point in cadmium chloride A [17].

For cadmium chloride, the results in FESEM were only from cadmium chloride A and D, as the lowest amount of cadmium chloride will be compared with the highest. Blood morphology cannot be seen clearly for cadmium chloride, as an interaction occurs between cadmium chloride and blood. It is probably because of the solubility of cadmium chloride in the blood. The morphology can be compared through an image of the clotted blood for sample cadmium chloride A and D. The clotted blood can be seen clearly from the sample cadmium chloride A image. But as more cadmium chloride was added, the image sputtered and congregated [18].

The image in cadmium chloride D shows that the sample congregation was evident compared to cadmium chloride A. A high amount of cadmium chloride was present in the sample of cadmium chloride D. As in the congregate state, the concentration of the blood is low because of cadmium chloride chemical interaction in the solution. The blood concentration is low, as the image sputters and shows a high amount of cadmium chloride and a low amount of blood in the sample [19]. As the blood concentration is low, it eventually affects the human body as it can't function perfectly.

As cadmium chloride is a carcinogen to humans, it can cause a higher risk of lung cancer. It can be explained that when cadmium chloride is in blood, it can cause toxicity to a genetic cell when it reacts with oxygen, thus obstructing DNA production and regeneration [20]. Cadmium chloride causes a significant problem in the kidney and liver as these two organs produce metallothionein. The metallothionein will bind with most metals, including cadmium chloride.

The condition of the blood sample in cadmium chloride A and cadmium chloride D was the hypertonic solution. It is when too much water comes out of the cell and causes it to undergo plasmolysis. The cell loses too much water as a result of the toxicity of the cadmium chloride. It then triggered the turgor pressure and caused the pressure to drop [21]. The cell walls then peel off from the protoplasm inside the cell as the pressure drops. This condition makes the cell loosely or flaccid when there is a space between the protoplasm and the cell wall and gives a chance for the hypertonic solution to fill in between the space.

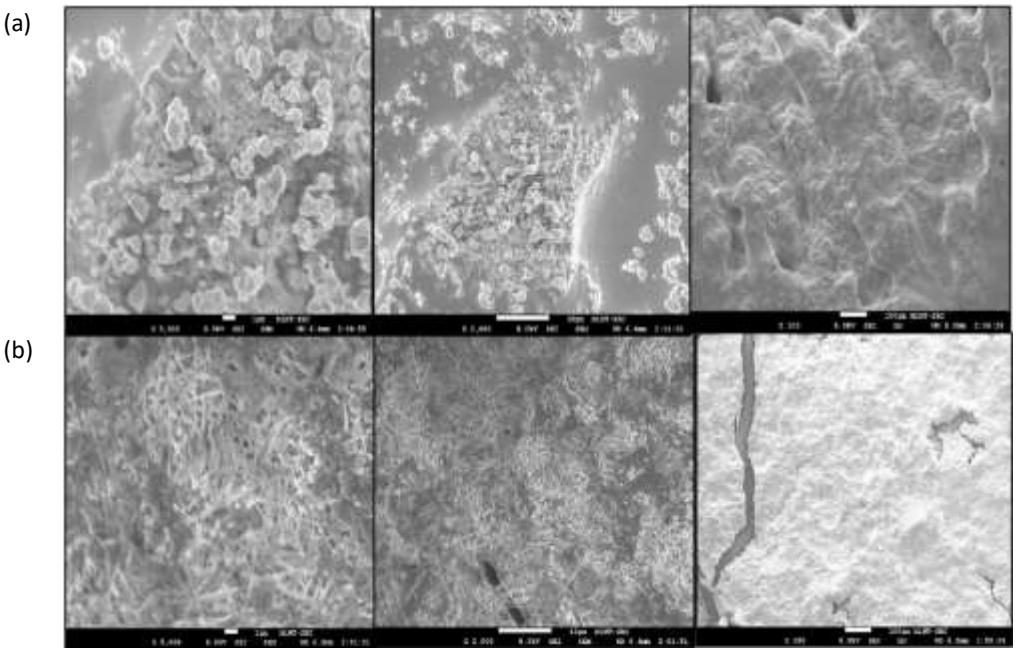


Fig. 3. Morphology of sample cadmium chloride at a magnification of 5000x, 2000x and100x for (a) A (b) D

The graph of absorbance was plotted using absorbance value against wavelength in nanometres. The graph shows that the absorbance value is set to 500nm to 800nm as haemoglobin extinction is between wavelengths [27]. Absorbance is a term that defines the ability of a solution to absorb light at a specific wavelength. It is also a light intensity ratio before and after light absorption in the UV-Vis [22]. Through the experiment, the wavelength was set between 300 to 800 nm. From Figure 4, the absorbance peak can be found at a wavelength of 666 nm. At 666 nm, the absorbance value of the cadmium chloride A sample is 3.556. For cadmium chloride sample B, the absorbance value is at 3.209. The absorbance values for cadmium chloride C and D are 2.887 and 2.71, respectively.

The average peak of absorbance value was obtained for lead at 590 nm. For the Lead A sample, the absorbance value is at 3.931. For sample Lead B, the absorbance value is 3.876. Lead C and D's absorbance values were 3.572 and 3.687, respectively. A higher value of absorbance corresponds to a higher concentration of a solution [23]. In this study, a higher absorbance value determines the blood concentration as it can absorb more light. For the lead sample, lead A had the highest number of absorbances, as the blood concentration was high. The lower the absorption value, the lower the blood concentration in the sample. The same was applied to the cadmium chloride sample. A sample of cadmium chloride A has the highest absorbance value, as it has a high blood concentration. To conclude, the higher the number of lead and cadmium chloride added, the lower the blood concentration. As low blood concentration increases, oxygen and nutrients cannot meet the body's function needs [25].

The pH level or potential hydrogen is a quantification concentration of hydrogen ions. The pH ranges from 0 to 14 and a solution below 7 is acidic. If it is higher than 7, it is an alkaline state. The solution is neutral if the pH level is at 7. For a healthy body, the blood must be between 7.35 and 7.45.

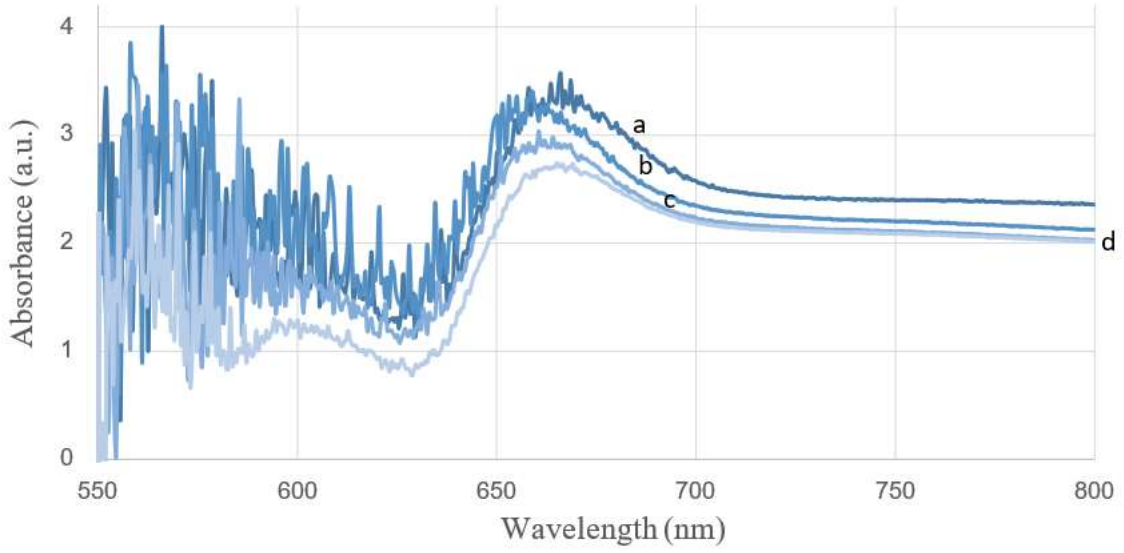


Fig. 4. Absorbance graph for cadmium chloride sample (a) A (b) B (c) C (d) D

Table 2
Results of pH metre for each sample

Name	Descriptions	pH Level
Blood	Substrate powder haemoglobin from bovine and distilled water	7.35
Cadmium chloride	Cadmium chloride powder and distilled water	3.84
Lead metal powder	Lead metal powder and distilled water	10.15
Lead A	Blood and 2 g lead metal powder	7.73
Lead B	Blood and 4 g lead metal powder	8.16
Lead C	Blood and 6 g lead metal powder	9.15
Lead D	Blood and 8 g lead metal powder	9.82
Cadmium chloride A	Blood and 2 g of cadmium chloride	3.99
Cadmium chloride B	Blood and 4 g of cadmium chloride	3.31
Cadmium chloride C	Blood and 6 g of cadmium chloride	3.05
Cadmium chloride D	Blood and 8 g of cadmium chloride	1.76

Based on the results in Table 2 above, the blood sample pH was 7.35, which is normal. A body must have a balanced pH level as it is one of the first lines of body defence. It also needs to be balanced to maintain the homeostasis process in the body. It is a process in which the body needs to make sure an equilibrium process is achieved in the body. In the homeostasis process, a chemical reaction occurs in the body and requires an enzyme to perform the process. The enzyme will not function properly if the pH level is not balanced.

If the pH level is low, it is in an acidic state. If the pH level is high, it is in an alkaline state. From the results above, the Lead sample shows an alkalinity. The ideal pH level in blood is said to be 7.4, whereas an alkaline side is at a neutral level. A normal blood pH in humans or mammals is said to be precise and sustained at a level of 7.40 [28]. On sample Lead A, the pH level was at 7.73. The pH level exceeded seven for lead samples B, C, D and E, proving its alkalinity. The condition of blood that contains more alkalis is called alkalosis. It is a condition where the blood pH is not balanced anymore and at abnormally high levels of pH. If an alkalosis condition occurs in one's body, it can cause lung disease, liver disease and also kidney failure. The alkalosis condition of the body also can cause hypothyroidism or it can define a condition of a thyroid that is not active in producing enough thyroid hormone. Alkalinity in the body can also cause the stomach or digestion organ to produce low hydrochloric acid. When it can't make enough hydrochloric acid, it can disturb the digestion process in the stomach and lead to another disease since the digestive system can't perform well.

Cadmium chloride and blood samples showed acidity when the pH was between 3.99 and 1.55. This condition was referring as acidosis. It is a condition where an acid level is abnormally high in the body. When a fluid in the body or blood turns acidic, it can lead to another severe problem. Acidic conditions in the body can cause body drowsiness. Keeping a balanced pH level in the body is also essential, but it can cause many side effects. In an acidic condition, it is advantageous for bacteria, viruses and unwanted organisms to prosper rapidly in the body. It starts when it causes insufficient oxygenation levels in the body, leading to a low level of oxygen gas in the blood. When oxygen in the blood cannot be delivered functionally, it causes the spread of viruses and bacteria in the body, which eventually causes cancer.

The acidosis condition also causes severe destruction of vital organs. It is when a body detects a high level of acid; it stores the acid in the fat cell to stop the acidity from causing damage in the tissues; so, if the level is too high, more fat cells are produced to store the undesirable acid in the body. The acidosis condition can also cause calcium depletion in bone and muscle failure to contract [28]. A metabolic disease also occurs if the pH level is not balanced at 7.4, which is slightly alkaline neutral.

4. Conclusion

Heavy metal is a metal that has a high potential for toxicity. Heavy metals such as lead and cadmium chloride used in this research affect the morphology of blood, blood concentration and pH levels. The blood morphology was observed when an amount of lead and cadmium chloride was added—the blood's morphology changes when different amounts of lead and cadmium chloride are added. The morphology of blood was observed as the morphology of blood can define the functionality of transporting oxygen. The level of pH of the sample gives an acidity and alkaline condition as the level of pH is below seven and above 7.

The blood samples were added with lead and cadmium chloride with different amounts. It ranges from 2 g to 8 g of lead and cadmium chloride. All the samples were tested using UV-Vis to analyse the blood concentration level after adding the lead and cadmium chloride. The absorbance value corresponds to the concentration of the blood. A higher number of absorbances has a high blood concentration in the sample. The blood pH level also changed when lead and cadmium chloride were added to the blood sample. Lead samples show an alkaline condition, while cadmium chloride shows an acidosis condition.

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