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The Ecological Risk Assessment of Ash Toxicity in the Freshwater Crustacean *Simocephalus vetulus* Schϕdler 1858

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Abstract

The estimating of ash toxicity collected from Durah power plant (DPP) which is located in Baghdad Governorate was done by exposed cladoceran *Simocephalus vetulus* to different ash concentrations. Thus, the first of its kind study by assessing the toxic effect of these effluents in the selected laboratory individual's food chain. The acute toxicity test of ash was assessed by LC_{50} and mortality percentage. LC_{50} of ash on *S. vetulus* were 0.14, 0.11 and 0.1 ppt during 24, 48 and 72 hr., respectively. On the other hand, it was shown that increasing the concentrations of ash leads to an increase mortality percentage. It was observed that the maximum mortality percentage (LC100) when exposed to 0.2 and 0.19 ppt at 24 hr. of exposing. On the other hand, the minimum mortality percentages were 0% (LC0) when exposed to 0.1 ppt at 24 hr., this percentage increased to 43% and 56% after 48 and 72 hr., respectively. Also, some obvious changes were observed in the animal behavior, such as slowness at first, then settle on the bottom of the beakers with stopped the antenna and thoracic appendages followed by a weak in a heartbeat. It was shown that the ash concentrations result in inhibiting the survival and increased the mortality percentage, this may be related with the presence of the toxic constituents in ash and change in pH level which was caused a harmful effect.

Keywords: Toxicity; LC_{50}; Cladocera, *Simocephalus vetulus*; Ash.

تقييم المخاطر البيئية لسمية الرماد في قشري المياه العذبة *Simocephalus vetulus* Schϕdler 1858

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الخلاصة

درست المخاطر البيئية المترتبة على الرماد الناتج من محطة كهرباء الدورة الواقعة في محافظة بغداد من خلال تعريض احد أفراد متفرعة اللوامس *Simocephalus vetulus* . ولهذا ، فإنها تعد دراسة الاولى من نوعها من خلال تقييم تأثير سمية هذه النفايات السائلة في أفراد مختبرية مختارة من السلسلة الغذائية. تم تحديد قيمة التركيز القاتل لنصف عدد الأفراد بالإضافة إلى احتساب النسبة المئوية للهلاكات خلال فتره التعريض. بلغت قيمة التركيز القاتل لنصف العدد 0.14 و 0.11 و 0.1 جزء بالالف بعد مرور 24 و 48

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و72 ساعة على التوالي من تعريض النوع لتراكيز الرماد المستخدمة, كما أظهرت نتائج الدراسة الحالية ان النسب المئوية للهلاكات قد تزايدت بشكل ملحوظ تزامنا مع ازدياد تراكيز الرماد المستخدمة, اذ سجل التركيزين 0.2 و0.19 جزء بالألف أعلى نسبة هلاكات LC_{100} خلال الأربعة وعشرين ساعة الأولى من التعريض, في الوقت الذي لم يسجل فيه التركيز 0.1 نسبة هلاك خلال الأربعة وعشرين ساعة الأولى بينما ارتفعت النسبة المئوية. للهلاك حتى بلغت 43% و56% بعد 48 و72 ساعة من التعريض للتركيز ذاته. كا تم تسجيل بعض التغيرات السلوكية للحيوان المدروس خلال فترة التعريض والمتمثلة بتباطؤ السباحة مع هبوط الكائن للقعر وتوقف اللواحق الصدرية وضعف نبض القلب. من خلال ماسبق أصبح من الواضح أن للرماد المستخدم التأثير السلبي على طول مده الحياة وبالتالي زيادة النسب المئوية للهلاكات, وقد يعزى سبب ذلك الى المكونات السامة التي يحتويها الرماد إضافة إلى قابلية الرماد في تغير قيمة الأس الهيدروجيني pH للوسط وبالتالي حدوث التأثير المؤذي للحيوان المعرض .

Introduction

Human civilization originated developed and thrived in places where there is easy access to freshwater sources [1]. The expansion of agriculture and industrial development has not only increased water consumption but also affected water quality. Water is easily polluted because of its great ability to dissolve substances [2]. Riverine ecosystem worldwide faces multiple pressures due to human interventions such as dams, channelization, deforestation, and irrigation, to name but a few, as well as a plethora of industrial and agricultural waterborne plethora emissions [3].

Power generating units are mega project, which require not only huge capital investment but also various natural resources like, fossil fuels and water, thus create an immeasurable and everlasting impacts on the environment and generate tremendous stress in the local-ecosystem, in spite of stringent government norms to control and mitigate the damages to the environment by the power plants. [4].

Major pollutants released by coal based power plant include sulphur, carbon, nitrogen, Poly Aromatic Hydrocarbons (PAHs), Poly Chlorinated biphenyl (PCBs), heavy metals and fly ash. Coal operated thermal power plant can be a source of pollution, because ash derived from burning coal containing heavy metals such as arsenic, cadmium, lead, mercury, iron, and zinc can contaminate a water body, presenting a potential hazard to the environment [5]. Due to its fine particle size 5 to 100 microns, it contaminates the aerial as well as the aquatic environment. So, the ecological risk assessment of ash collecting from Durah power plant (DPP) was the main aim in the present study by exposed to different of ash concentrations on cladoceran *Simocephalus vetulus*. Thus, the first of its kind study by assessing the toxic effect of these effluents in the selected laboratory individual's food chain.

Material and Methods

Study Area

The current study focuses on the effect of effluent discharge from Durah power plant (DPP) which is located in South-West of Baghdad Governorate on the right bank of Tigris River and discharged their toxicants effluents directly with simple and old treatment to this river. The plant is considered as one of the important industrial facilities in Iraq which it is located by 5.5 Km to the west of Durah refinery[6] Figure-1.

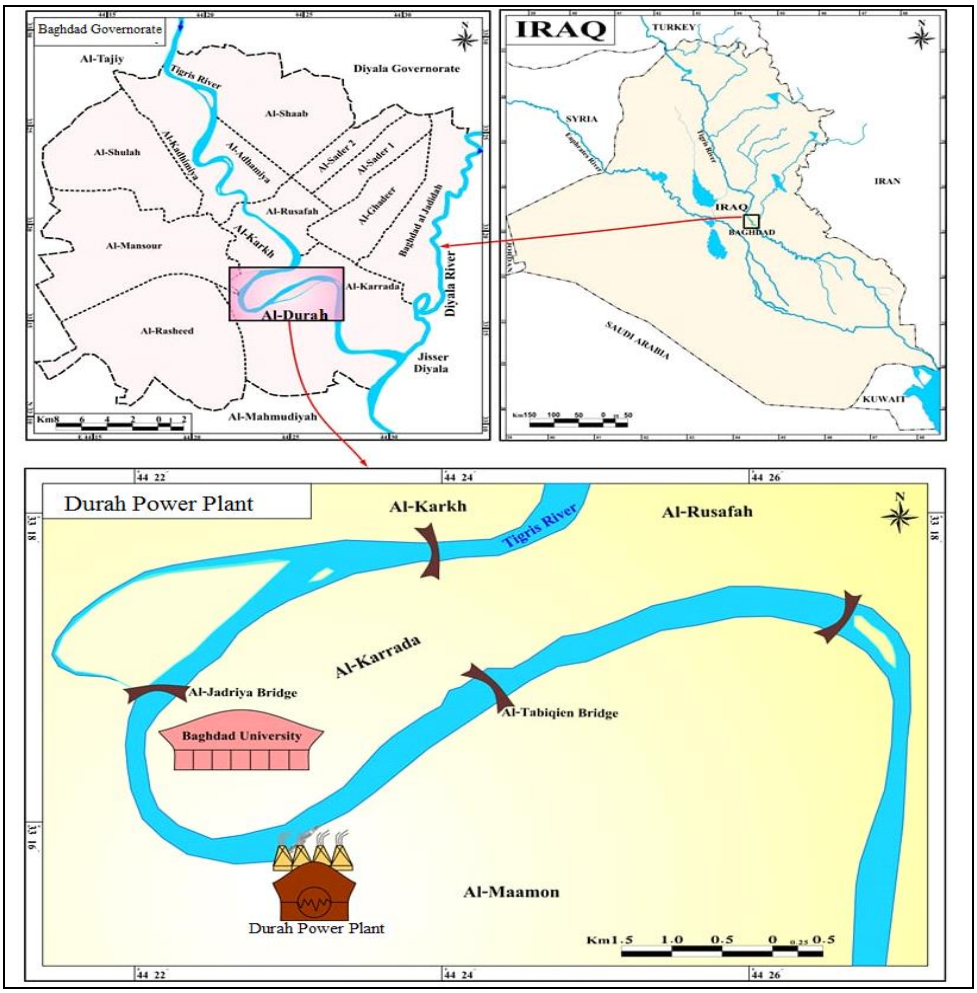

Figure 1- Maps of Iraq and Baghdad showing Durah power plant which located in Tigris River, mid of Iraq. Source: (Ministry of Water Resources, 2007.scal 1/100000).

The Samples Collection

The cladoceran samples were collected from two areas of Baghdad Governorate include: The channel which located behind Masjid Um-Alqura in the west of Baghdad and the channel which located around of the University of Baghdad in Al-Jadriya District. According to the collection process of Winsor [7]. The experimental selected species were *Simocephalus vetulus* Schϕdler 1858 which was collected by pouring river water through 55 mm plankton net. Following samples were placed in a plastic container and transported to the laboratory for isolation and identification to species taxonomic unite by using the dissecting microscope, Japanese made, type Olympus [8] and compound microscope type Olympus depending on the specific identification key [9;10].

Culture of Organisms and Exposure to Ash

The culture of *Simocephalus vetulus* was exposed to photoperiod 12/12 hour (light/dark) by using a bulb in the winter for emission heat and daylight lighting [11].

The culture temperature was ranged from 20± 3°C while the pH was ranged from 7.3 to 8.4 which was measured by pH meter, (pH 702 Inlop Instrument, manufactured by WTW Germany) [12].

The water of aquaria was aerated by using a Japanese air pump type (Rishing /610) supplied with an air regulator to control on the air bubbles formed in aquaria to prevent depletion of oxygen [13].

The water of aquaria was renewed every three days to prevent the accumulation of fungi and wastes, to avoid overcrowding, competition and to fill the shortage of dissolved oxygen as well as to prevent the change in pH value [14].

The dissolved oxygen concentration was ranged from 1-14mg/L which was measured by oxygen meter, type Oxi 315 and manufactured by Germany WIW, the culture was also fed on drops of mixed algae with the juice of salad until the acute toxicity test began [15, 16].

Before the acute toxicity test, about 120 pregnant females for *S. vetulus* were taken and isolated in a glass beaker (120 ml) until they oviposited.

To start the acute toxicity test, the healthy neonates (juveniles) with 24 h. aged were taken from the first or second brood [17]. During this period, the culture was fed by using algae with water renewed regularly [18].

Experiments were carried out in glass beakers (10 groups per treatment), 60 animals of *S. vetulus* (divided into 6 animals per ten groups) were used per control and in ash concentration (2, 1.5, 1, 0.7, 0.5, 0.4, 0.3, 0.2 and 0.1 ppt), in addition to control group.

The experimental ash concentrations were observed by consecutive dilutions of a stock solution. The concentration of ash stock solution was prepared by weighting 2gm of crude ash then dissolving in 1L of distilled water to prepared 2ppt and by using the dilution equation to prepare the minimum concentrations as the following equation below:

$C1 \times V1 = C2 \times V2$

All the concentrations were prepared from the same stock solution (2ppt) to obtain the other minimum concentration.

The cladoceran individuals were checked every day at the same hour to examine the mortality percentage.

Due to the death of all the individuals exposed to 2, 1.5, 1, 0.1, 0.5, 0.4, 0.3 and 0.2 ppt concentrations during less than 24 hours period and survival of individuals which exposed to 0.1 ppt, therefore, it is necessary to prepare the confined concentrations from 0.1- 0.2ppt by using 0.2 ppt as a stock solution which was prepared by weighting 2mg of crude ash then dissolving in 1L of distilled water, by using the dilution equation to prepared 0.19, 0.18, 0.17, 0.16, 0.15, 0.14, 0.13, 0.12 and 0.1 ppt concentrations.

During the acute exposure, no air and food were added, as well as no replaced to the test solution during this period [19]. The experiment of calculating median lethal concentration (LC 50) of *S. vetulus* was carried out in 24,48,72 and 96 hr. The end point or the animal's death was defined as:

1. Stopped the movement for 15 sec. after exposing to bright light [20].
2. External movement, the movement of the antenna and the thoracic appendages is stopped [21].
3. Using 10X microscope magnification to observe stopped cardiac and ensures the death [21].

The mortality percentages were determined for *S. vetulus* exposed to ash concentration through 72 hr. Mortality percentage was calculated by using the equation below as:

$$\text{Mortality percentage } \% = \frac{\text{Number of mortal animal in each conc.}}{\text{Total number of animals group}} \times 100$$

Toxicity and LC50 Assays

The LC50 was calculated as an interpolated value based on the percentage of deaths of test organisms at two or more concentrations. In one of the concentrations of deaths should be less than 50%, while the other should have deaths of more than 50% [22].

Data Analysis

The probit analysis includes the conversion of ash concentrations to opposite log and the mortality percentage to probit units. By using linear regression and curve estimation to get a curve and an equation for each exposure [22, 23].

Result and Discussion

The LC50 values were only observed in the period 24,48 and 72 hr. and as the following:0.14, 0.11, and 0.1 ppt respectively Figures-(2,3 and4).

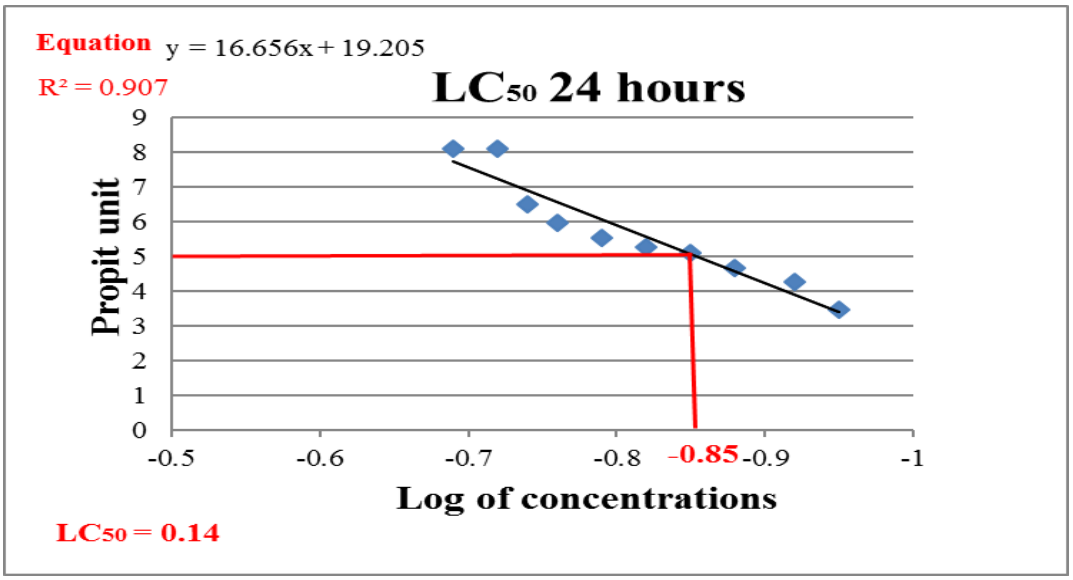

Figure 2- Median Lethal Concentration (LC50) of *S. vetulus* after 24 hr. of exposure

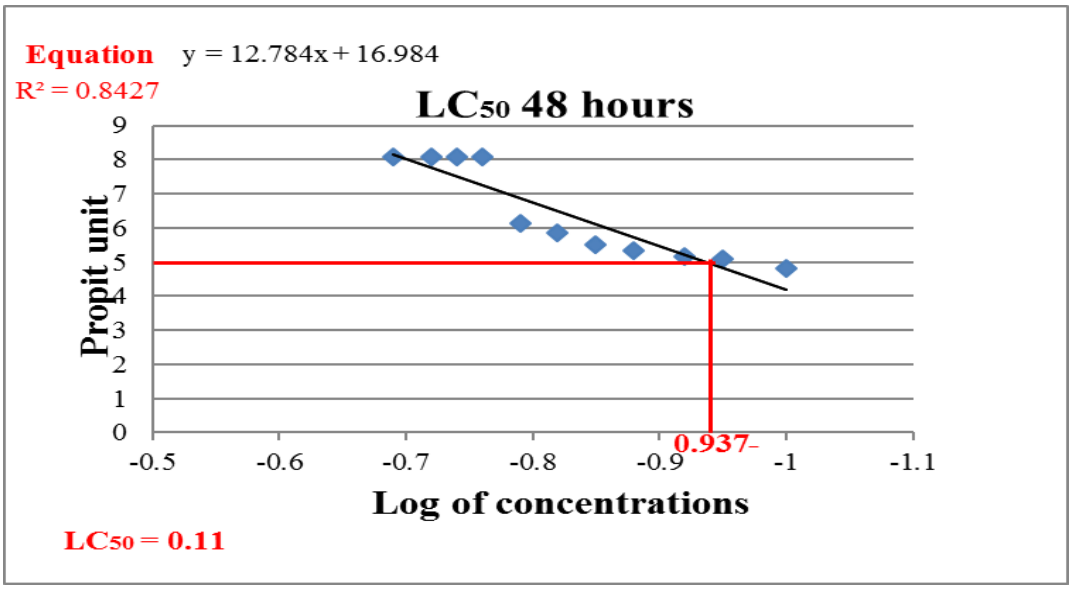

Figure 3- Median Lethal Concentration (LC50) of *S. vetulus* after 48 hr. of exposure.

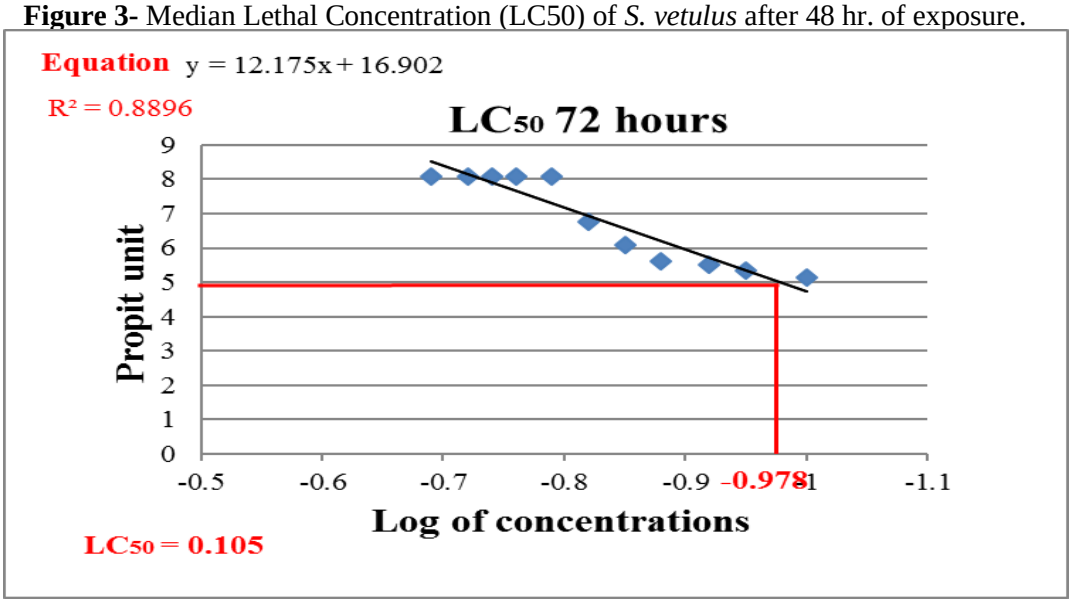

Figure 4- Median Lethal Concentration (LC50) of *S. vetulus* after 72 hr. of exposure.

The values of ash LC50 are lower than those reported by Othman [24] in their study, the LC50 value was 0.14 mg/L after 96 h. of exposed *Melanoides tuberculata* to Cu concentrations.
Whereas Schiffer [25] has reported that LC50 ranges from 0.60 to 2.17 mg/L when exposed *Ceriodaphnia quadrangular* and *Daphnia pulex* to vanadium concentrations.

In contrast, Al-Mussawi [26] found that LC50 values were ranged from 131 to 554 mg/L when she exposed *S. vetulus* to heavy metals concentrations.

The results showed high sensitivity of *S. vetulus* toward ash concentrations. Therefore, ash concentration has toxicity value higher than those reported by another toxicity test, and this was occurring from the lower values of LC50 which were observed in this study.
The LC50 values of the current study were near to the LC50 values which were founded by Sales [27] who observed the LC50 values were 0.45 and 0.44 mg/L respectively when exposed *Daphnia similis* and *Ceriodaphnia silvestre* to toxicity of arsenic (AsIII).
Due to higher mortality of ash concentrations exposed to *S. vetulus* in previous periods, the toxicity curves of 96 hr. in all acute experiments were absent, as a result no equation can be calculated after 96 h. of exposure because all probit units appeared as a one point and the curves began from number higher than 5.

This also means that number 5 was absent from the Y axis. This case agreement with another study such as the study of Meyer [28] and Martinez-Jeronimo [29] calculated the only LC50 after 48 hr., while Park [30] determined LC50 in 24 hr.

It was shown that the ash concentrations were inhibited the survival and increased the mortality percentage, this may be related to the presence of the toxic constituents and change in pH level which were caused a harmful effect [31].

Finally, the variability of the long exposure period depended on life stage, end points were used, increase or decrease in temperature, in addition to the sorted organisms that responsible for toxicity exhibition [32].

In a sense, Figure - 5 demonstrated the mortality percentage of *S. vetulus* which was exposed to acute concentrations of ash during 72 hr. It was observed that the higher mortality percentage 100% (LC100) when exposed *S. vetulus* to concentrations 0.2 and 0.19 ppt within the first 24 hr. of exposing. On the other hand, the minimum mortality percentages were 0% (LC0) when exposed to 0.1 ppt at 24 hr. this percentage increased to 43% and 56% after 48 and 72 hr. respectively.

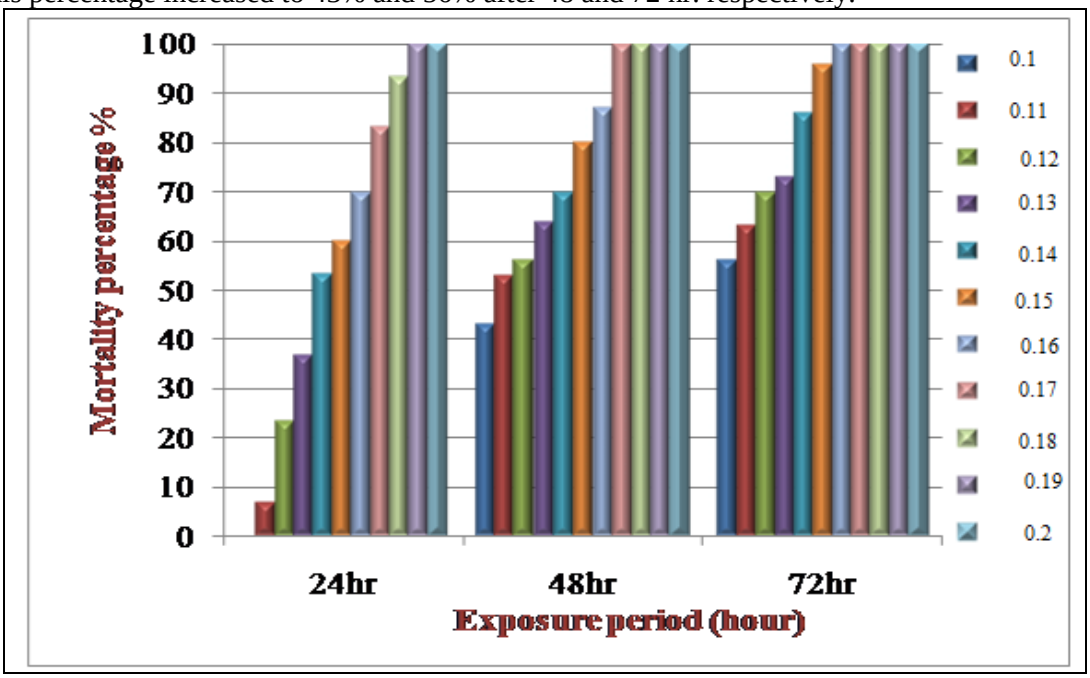

Figure 5- Mortality percentage % *S. vetulus d*uring the exposure period.

It was noted that the mortality percentages increased clearly with increasing ash concentrations. This agrees with the study of Ahmed and Khan [31] on Nematode: *Meloidogyne incognita* in which they observed that the mortality percentage was increased greatly with the test period prolonged (7th

day) when exposed to concentrations of fly ash. The sensitivity of the organisms should be increase clearly. This may be related to the synergistic effect of these toxic substances in ash concentrations [27]. Or whether, all groups during the acute exposure were not added any food, therefore this may be related to their ash particles have the ability to pass through individual membranes without the need of food [33], or may be attributed to morphology and particles diameter in the ash. In contrast, Qviberg [34] found that ash concentrations had an effect on *D. magna*, this may be related to metals anions and negative ions with caused in proving toxicity in the hardened ash come from lipophilic compounds. Therefore, in spite of higher dissolved oxygen concentrations supply through the whole test period *S. vetulus* don't have the ability to cope with ash respiration depletion.

However, heavy metals in ash had known to bioaccumulation through dietary exposure, as well as it's the propensity to biomagnified (increased in their concentrations via dietary uptake) [35].
Also, it was observed some obvious changes in the animal behavior, such as at first slowness, then settle on the bottom of the beakers with stopping the antenna and thoracic appendages followed by a weak in a heartbeat.

Finally, death was recorded as the end point of the animal. This case may be related to a near risk system for aquatic environmental quality [17].

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