Bio-energy concentration done by Dinosaurs at trophic level and suppression of other vertebrate animal species: A probable cause for mass extinction of Dinosaurs during Cretaceous period

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Abstract- The Dinosauria were the most successful land vertebrates ever, and survived for 165 million years, until most became extinct 65 million years ago. Dinosaurs first appeared about 230 million years ago, at the beginning of the late Triassic period. By the end of the Triassic period, dinosaurs dominated the then continent Pangaea, possibly contributing to the extinction of many other reptiles. Though, dinosaurs were successful, but they could not manage to survive longer after 165 million years, due to a mass extinction which happened during Cretaceous period. Sun's solar energy is the main source of energy for sustenance of all life forms on earth. An imbalance of energy within the biological system of biosphere and non-sustenance could be possible reason for mass extinction of dinosaurs.

Index Terms- Dinosaurs, Bio-energy, Triassic period, Energy transformation, Cretaceous period, Energy concentration.

I. Introduction

The Dinosaurs were a large group of reptiles that were the dominant land vertebrates (animals with backbones) for most of the Mesozoic era (245-65 million years ago). They appeared some 230 million years ago and were distinguished from other scaly, egg-laying reptiles by an important feature: dinosaurs had an erect limb stance. This enabled them to keep their bodies well above the ground, unlike the sprawling and semi-sprawling stance of other reptiles. Dinosaurs ranged in size from smaller than a domestic cat to the biggest land animals ever known. The Dinosauria were the most successful land vertebrates ever, and survived for 165 million years, until most became extinct 65 million years ago. Dinosaurs first appeared about 230 million years ago, at the beginning of the late Triassic period. Among the earliest dinosaurs were the carnivorous herrerasaurids, such as *Herrerasaurus* and *Staurikosaurus.* Early herbivorous dinosaurs first appeared in late Triassic times and included *Plateosaurus* and *Technosaurus* [6]. By the end of the Triassic period, dinosaurs dominated the then continent Pangaea, possibly contributing to the extinction of many other reptiles. This phenomenon of suppression of other life forms (reptiles) is actually considered significant in the present investigation of concept of mass extinction. Though, dinosaurs were successful, but they could not manage to survive longer after 165 million years, due to a mass extinction which happened during Cretaceous period. So far no evidence suggested the reasons for this mass extinction. Hence, an investigation has been initiated for the possible reason of this mass extinction. The present review is highly significant in the present day, as the human population is becoming heavily populated and they are suppressing other flora and fauna.

II. Early sign of life forms

The earth formed from a cloud of dust and gas drifting through space about 4,600 million years ago. The earth crust is the solid outer shell of the earth. It includes continental curst (about 40 kilometres thick) and oceanic crust (about six kilometers thick). When the earth formed about 4,600 million years ago its atmosphere consisted of volcanic gases with little oxygen, making it hostile to most forms of life. For almost a thousand million years after its formation, there was no known life on earth. One large super continent, Gondwana, was situated over the southern polar region, while other smaller continents were spread over the rest of the world. Constant movement of the earth's crustal plate carried continents across the earth's surface. The first primitive life-forms emerged around 3,400 million years ago, in shallow warm seas. The buildup of oxygen began to form a shield of ozone around the earth, protecting living organisms from the sun's harmful rays and helping to establish an atmosphere in which life could sustain itself. The first simple, sea-dwelling organic structures appeared about 3,500 million years ago; they may have formed when certain chemical molecules joined together. Prokaryotes, single-celled micro-organisms such as blue-green algae, were able to photosynthesize, and thus produce oxygen. A thousand million years later, sufficient oxygen had built up in the earth's atmosphere to allow multicellular organisms to proliferate in the Precambrian seas (before 570 million years ago). Soft bodied jellyfish, corals, and seaworm flourished about 700 million years ago. Trilobates, the first animals with hard body frames, developed during the Cambrian period (570-510 million years ago). However, it was not until the beginning of the Devonian period (409-363 million years ago) that early land plants, such as *Asteroxylon,* formed a water retaining cuticle, which ended their dependence on an aquatic environment. About 360 million years ago, the first amphibians crawled onto the land, although they probably still returned to the water to lay their soft eggs. By the time the first reptiles and synapsids appeared late in the

Carboniferous, animals with backbones had become fully independent of water [6]. Over a period, gradually many complex life forms were originated in marine, aquatic and terrestrial ecosystem. Whether it is aquatic or marine or terrestrial ecosystem, life forms needs energy to grow, reproduce, make flight, walk, run *etc*. The concept of dynamic bioenergetics and budgeting was put forth by S.A.L.M. Kooijman during 1993 [7]. According to this theory, every living organism on planet earth needs energy for their survival. During, entire life cycle these life forms need energy till death in the form of food. Hence, biological system on earth crust was structured in such a way that all living organisms should be nourished by the basic producer – the autotrophs *i.e* plants in case of terrestrial ecosystem and diatoms as primary producers in case of marine ecosystem. The theory of bioenergetics and transformation says that energy which is trapped by the autotrophs like plants by the process of photosynthesis is the primary source of energy which is responsible for the sustenance of all other life forms on earth crust. With this perspective a review has been made to substantiate the reasons for mass extinction of dinosaurs during cretaceous period.

Triassic Period:

The Triassic period (250-200 million years ago) marked the beginning of what is known as the Age of the Dinosaurs (the Mesozoic era). During this period, the present-day continents were massed together, forming one huge continent known as Pangaea. This land-mass experienced extremes of climate, with lush green areas around the coast or by lakes and rivers, and arid deserts in the interior. The only forms of plant life were non-flowering plants, such as conifers, ferns, cycads, and ginkgos; flowering plants had not yet evolved. The principal forms of animal life included diverse, often gigantic, amphibians, rhynchosaurs ("beaked lizards"), and primitive crocodilians. Dinosaurs first appeared about 230 million years ago, at the beginning of the late Triassic period. Among the earliest dinosaurs were the carnivorous (flesh eating) herrerasaurids, such as *Herrerasaurus* and *Staurikosaurus.* Early herbivorous (Plant eating) dinosaurs first appeared in late Triassic times and included *Plateosaurus* and *Technosaurus.* By the end of the Triassic period, dinosaurs dominated Pangaea, possibly contributing to the extinction of many other reptiles [6].

Jurassic Period:

The Jurassic period, the middle part of the Mesozoic era, lasted from 199 to 145 million years ago. During Jurassic times, the land-mass of Pangaea broke up into the continents of Gondwana and Laurasia, and sea-levels rose, flooding areas of lower land. The Jurassic climate was warm and moist. Plants such as ginkgos, horsetails, and conifers thrived, and giant redwood trees appeared, as did the first flowering plants. The abundance of plant food coincided with the proliferation of herbivorous (plant eating) dinosaurs, such as the large sauropods (e.g., *Diplodocus*) and stegosaurs (e.g., Stegosaurus). Carnivorous (flesh eating) dinosaurs, such as *Compsognathus* and *Allosaurus*, also flourished by hunting the many animals that existed -among the other dinosaurs. Further Jurassic animals included shrew-like mammals, and pterosaurs (flying reptiles), as well as plesiosaurs and ichthyosaurs (both marine reptiles) [6].

Createaceous period:

The Mesozoic era ended with the Cretaceous period, which lasted from 146 to 65 million years ago. During this period, Gondwana and Laurasia were breaking up into smaller land-masses that more closely resembled the modern continents. The climate remained mild and moist but the seasons became more marked. Flowering plants, including deciduous trees, replaced many cycads, seed ferns, and conifers. Animal species become more varied, with the evolution of new mammals, insects, fish, crustaceans, and turtles. Dinosaurs evolved into a wide variety of species during Cretaceous times; more than half of all known dinosaurs-including *Iguanodon, Deinonychus, Tyrannosaurus* and *Hypsilphodon*-lived during this period. At the end of the Cretaceous period, however, most dinosaurs became extinct. The reason for this mass extinction is unknown but it is thought to have been caused by climate changes due to either a catastrophic meteor impact with the Earth or extensive volcanic eruptions [6]. Hence, nature has selected dinosaurs to make them extinct. So, this article is to find out the reason for selection of dinosaurs being mass extinct. The concept of mass extinction is entirely different from that of extinction of single species over a period. For example today's Tiger population around the world is considered to be an endangered species *i.e.* it is going to get extinct. The reason for extinction of Tiger population would be loss of habitat, poaching, lower reproductive potential and solitary behavior. But whereas mass extinction process done by nature would be made to completely vanish some group of animals, which sought to consume more biological energy leading to suppression of other flora and fauna. During this mass extinction process, the dominant non-flowering plants were almost lost along with the dinosaurs. It is believed that the reason for selection of animal species to be extinct may be evading the rules of nature or deviating from the sustenance of biological system on earth crust. Sun is the main energy source for all life forms on earth. In this regard, Sun's light energy is transformed into biological energy by the photosynthetic autotrophs.

Forms of energy:

The word energy was derives from the Ancient Greek word 'energeia' which means activity and operation, which possibly appears for the first time in the work of Aristotle [1].The total energy of a system can be subdivided and classified in various ways. For example, classical mechanics distinguishes between kinetic energy, which is determined by an object's movement through space, and potential energy, which is a function of the position of an object within a field. It may also be convenient to distinguish gravitational energy, thermal energy and several types of nuclear energy, electric energy and magnetic energy, among others. Many of these classifications overlap; for instance, thermal energy usually consists partly of kinetic and partly of potential energy.

Some types of energy are a varying mix of both potential and kinetic energy. An example is mechanical energy which is the sum of kinetic and potential energy in a system. Elastic energy in materials is also dependent upon electrical potential energy (among atoms and molecules), as is chemical energy, which is stored and released from a reservoir of electrical potential energy between electrons, and the molecules or atom nuclei that attract them.

Heat and work are special cases in that they are not properties of systems, but are instead properties of *processes* that transfer energy. In general how much energy is transferred among objects in certain ways during the occurrence of a given process. Heat and work are measured as positive or negative depending on which side of the transfer we view them from.

Potential energy are often measured as positive or negative depending on whether they are greater or less than the energy of a specified base state or configuration such as two interacting bodies being infinitely far apart. Wave energies (such as radiant or sound energy), kinetic energy, and rest energy are each greater than or equal to zero because they are measured in comparison to a base state of zero energy: “no wave”, “no motion”, and “no inertia”, respectively.

Energy in Physical aspects:

In physics, energy is a property of objects which can be transferred to other objects or converted into different forms [2]. The “ability of a system to perform work” is a common description, but it is misleading because energy is not necessarily available to do work [3]. For instance, in SI units, energy is measured in joules, and one joules is defined “mechanically”, being the energy transferred to an object by the mechanical work of moving it a distance of 1 metre against a force of 1 Newton. However, there are many other definitions of energy, depending on the context, such as thermal energy, radiant energy, electromagnetic, nuclear, etc., where definitions are derived that are the most convenient.

Common energy forms include the kinetic energy of a moving objects, the potential energy stored by an object’s position in a force field (gravitational, electrical or magnetic), the elastic energy stored by stretching solid objects, the chemical energy released when a fuel burns, the radiant energy carried by light, and the thermal energy due to an object’s temperature. All of the many forms of energy are convertible to other kinds of energy. In Newtonain physics, there is a universal law of conservation of energy which says that energy can be neither created nor be destroyed; however, it can change from one form to another.

For “closed systems” with no external source or sink of energy, the first law of thermodynamics states that a system’s energy is constant unless energy is transferred in or out by mechanical work or heat, and that no energy is lost in transfer. This means that it is impossible to create or destroy energy. While, heat can always be fully converted into work in a reversible isothermal expansion of an ideal gas, for cyclic processes of practical interest in heat engines. The second law of thermodynamics states that the system doing work always loses some energy as waste heat. This creates a limit to the amount of heat energy that can do work in a cyclic process, a limit called the available energy. Mechanical and other forms of energy can be transformed in the other directions into the thermal energy without such limitations. The total energy of a system can be calculated by adding up all forms of energy in the system.

Examples of energy transformation include generating electric energy from heat via steam turbine, or lifting an object against gravity using electrical energy driving a crane motor. Lifting against gravity performs mechanical work on the object and stores gravitational potential energy in the object. If the object falls to the ground, gravity does mechanical work on the object which transforms the potential energy in the gravitational field to the kinetic energy released as heat on impact with the ground. Our Sun transforms nuclear potential energy to other forms of energy: its total mass does not decrease due to that in itself, but its mass does decrease when the energy escapes out to its surroundings, largely as radiant energy.

Energy in chemical aspects:

In the context of chemistry, energy is an attribute of a substance as a consequence of its atomic, molecular or aggregate structure. Since a chemical transformation is accompanied by a change in one or more of these kinds of structure, it is invariably accompanied by an increase or decrease of energy of the substances involved. Some energy is transferred between the surroundings and the reactants of the reaction in the form of heat or light; thus the products of a reaction may have more or less energy than the reactants. A reaction is said to be exergonic if the final state is lower on the energy scale than the initial state; in the case of endergonic reactions the situation is the reverse. Chemical reactions are invariably not possible unless the reactants surmount an energy barrier known as the activation energy. The speed of a chemical reaction (at given temperature T) is related to the activation energy *E*, by the Boltzmann’s population factor $e^{-E/kT}$ – that is probability of molecule to have energy greater than or equal to *E* at the given temperature *T*. This exponential dependence of a reaction rate on temperature is known as the Arrhenius equation. The activation energy necessary for a chemical reaction can be in the form of thermal energy.

Energy in biological aspects:

In biology, energy is an attribute of all biological systems from the biosphere to the smallest living organisms. Within an organism it is responsible for growth and development of a biological cell or an organelle of a biological organism. Energy is thus often said to be stored by cells in the structures of molecules of substances such as carbohydrates (including sugars), lipids, and proteins, which release energy when reacted with oxygen in respiration. In human terms, the human equivalent (H-e) (Human energy conversion) indicates, for a given amount of energy expenditure, the relative quantity of energy needed for human metabolism, assuming an average human energy expenditure of 12500 kj per day and a basal metabolic rate of 80 watts. For example, if our bodies run (on average) at 80 watts, many times the 746 watts in one official horsepower. For tasks lasting a few minutes, a fit human can generate perhaps 1,000 watts. For an activity that must be sustained for an hour, output drops to around 300; for an activity kept up all day, 150 watts is about the maximum. The human equivalent assists understanding of energy flows in physical and biological systems by expressing energy units in human terms: it provides a “feel” for the use of a given amount of energy.

Sunlight is also captured by plants as *chemical potential energy* in photosynthesis, when carbon dioxide and water (two low energy compounds) are converted into the high-energy compounds carbohydrates, lipids, and proteins. Plants also release oxygen during photosynthesis, which is utilized by living organisms as an electron acceptor, to release the energy of carbohydrates, lipids and proteins. Release of the energy stored during photosynthesis as heat or light may be triggered suddenly by a spark, in a forest fire, or it may be made available more slowly for animal or human metabolism, when these molecules are ingested, and catabolism is triggered by enzyme action.

Any living organisms relies on an external source of energy-radiation from the Sun in the case of green plants, chemical energy in some form in the case of animals to be able to grow and reproduce. The daily 1500-2000 Calories (6-8MJ) is recommended for a human adult are taken as a combination of oxygen and food molecules, the latter mostly carbohydrates and fats, of which glucose ($C_6H_{12}O_6$) and stearin ($C_{57}H_{110}O_6$) are convenient examples. The food molecules are oxidized to carbon dioxide and water in the mitochondria

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

$$C_{57}H_{110}O_6 + 81.5O_2 \longrightarrow 57CO_2 + 55H_2O$$

and some of the energy is used to convert ADP into ATP.

$$ADP + HPO_4^{2} \longrightarrow ATP + H_2O$$

The rest of the chemical energy in O_2 [4] and the carbohydrate or fat is converted into heat: the ATP is used as a sort of "energy currency", and some of the chemical energy it contains is used for other metabolism when ATP reacts with OH groups and eventually splits into ADP and phosphate (at each stage of a metabolic pathway, some chemical energy is converted into heat). Only a tiny fraction of the original chemical energy is used for work:

gain in kinetic energy of a sprinter during a 100 m race: 4kj

gain in gravitational potential energy of a 150 kg weight lifted through 2 metres: 3 kj

Daily food intake of a normal adult: 6-8 MJ

It would appear that living organisms are remarkably inefficient (in the physical sense) in their use of the energy they receive (chemical energy or radiation) and it is true that most real machines manage higher efficiencies. In growing organisms the energy that is converted to heat serves a vital purpose, as it allows the organism tissue to be highly ordered with regard to the molecules it is built from. The second law of thermodynamics states that energy (and matter) tends to become more evenly spread out across the universe: to concentrate energy (or matter) in one specific place, it is necessary to spread out a greater amount of energy (as heat) across the remainder of the universe ("surroundings"). Simpler organisms can achieve higher energy efficiencies than more complex one, but the complex organisms can occupy ecological niches that are not available to their simpler brethren. The conversion of a portion of the chemical energy to heat at each step in a metabolic pathway is the physical reason behind the pyramid of biomass observed in ecology: to take step in the food chain, of the estimated 124.7 Pg/a of carbon that is fixed by photosynthesis, 64.3 Pg/a (52%) are used for the metabolism of green plants [5] *i.e.* reconverted into carbon dioxide and heat.

Energy in earth science aspects:

In geology, continental drift, mountain ranges, volcanoes, and earthquakes are phenomena that can be explained in terms of energy transformation in the Earth's interior, while meteorological phenomena like wind, rain, hail, snow, lightening, tornadoes and hurricane are all result of energy transformation brought about by solar energy on the atmosphere of the planet Earth.

Sunlight may be stored as gravitational potential energy after it strikes the Earth, as (for example) water evaporates from oceans and is deposited upon mountain(where, after being released at a hydroelectric dam, it can be used to drive turbines or generators to produce electricity). Sunlight also drives many weather phenomena, save those generated by volcanic events. An example of a solar-mediated weather event in a hurricane, which occurs when large unstable areas of warm ocean, heated over month, give up some of their thermal energy suddenly to power a few days of violent air movement.

In a slower process, radioactive decay of atoms in the core of the earth releases heat. This thermal energy drives plate tectonics and may lift mountains, via orogenesis. This slow lifting represents a kind of gravitational potential energy storage of the thermal energy, which may be later released to active kinetic energy in landslides, after a triggering event. Earthquakes also release stored elastic potential energy in rocks, a store that has been stored as potential energy in the Earth's gravitational field or elastic strain (mechanical potential energy) in rocks. Prior to this, they represent release of energy that has been stored in heavy atoms since the collapse of long-destroyed supernova stars created these atoms.

Energy in Cosmological aspects:

In cosmology and astronomy the phenomena of stars, nova, supernova, quasars and gamma-ray bursts are the universe's highest-output energy transformation of matter. All stellar phenomena (including solar activity) are driven by various kinds of energy transformation. Energy in such transformation is either from gravitational collapse of matter (usually molecular hydrogen) into various classes of astronomical objects (stars, black holes, etc.,) or from nuclear fusion (of lighter elements, primarily hydrogen). The nuclear fusion of hydrogen in the Sun also releases another store of potential energy which was created at the time of Big Bang. At that time, according to theory, space expanded and the universe cooled too rapidly for hydrogen to completely fuse into heavier elements. This meant that hydrogen represents a store of potential energy that can be released by fusion. Such fusion process is triggered by heat and pressure generated from gravitational collapse of hydrogen clouds when they produce stars, and some of the fusion energy is then transformed into sunlight.

Bioenergetics, transformation and concept of mass extinction:

Since all the organisms are serving as food for other life forms at the trophic level organization, all living organisms on earth crust are called bio-energy. Hence, bio-energy means biological energy which includes bacteria, protozoa, fungus, algae, plants, animals *etc.*, Bio-energy is the stored form of energy which was actually derived from solar energy. This bio-energy is spread on earth crust and they are confined only to the biosphere. Broadly bio-energy has been classified into autotrophic bio-energy and dependent bio-energy. Examples of autotrophic bio-energy is blue green algae, diatoms and photosynthesizing plants; and examples of dependent bio-energy is all the animals and some plants which are parasitic in nature. In the absence of autotrophic bio-energy, dependent bio-energy cannot exist on earth. In this regard, without any hesitation, it would be the autotrophic living organism which had originated first on earth. Bio-energy on earth is present in variation. The variation of bio-energy on planet earth is a peculiar feature in comparison with other planet. The diversity of bio-energy is due to variation in topography, climate, geography and other physio-chemicals parameters. The bio-energy also have interaction with atmospheric and geo-meterological factors like soil, water, air, rain and sea water. All the bio-energy has the main constituent 'water' and it plays a major role in buildup of bio-energy. The life forms on earth are nothing but concentrated complex biological energy entity with 'water' as the major constituent. Bio-energy also contains various inorganic chemicals and biochemical. One more important principle in energy transformation theory is bio-energy is self replicative. Self replication can be possible by two important principle namely asexual and sexual reproductions. The principle of replication is unique is biological system of earth. Among life form, except autotrophs, all have the ability to sense. Sensing of living organisms is possible by the presence of sense organs which are associated with central and accessory nervous system of complex biological system. The autotrophic living organisms mostly lack the sensing capacity and hence autotrophs are considered to be the main source of energy for dependent organisms. Ethically, for this reason, certain group of population in India feed only on food originated form plants (Vegetarians). Hence, nature was structured in such a way to maintain a balance of energy within the biological system. For this reason, super sized animals like elephants of today world, have lower reproductive potential than others in trophic level, as they are serving as a food (bio-energy) for the higher animals. In this regard, nature is a perfectly automated system with respect to maintenance of biodiversity from the time of origin of early life. Hence, nature tends to maintain a biological balance between organisms. However, the top trophic level carnivorous animals could manage to rule out this principle leading to concentration of bio-energy at the highest trophic level. During cretaceous period, the many forms of dinosaurs are mostly super sized with higher reproductive potential, which leads to concentration of bio-energy at the trophic level. This leads to non-sustenance and a block in the biogeochemical cycle, which usually leads to over suppression of lower level animals. If the populations of certain animal species were increased, nature tends to suppress the population by various factors like creating disease outbreak; competitions between organisms for share of territory, food, mate etc. However, dinosaurs had mange to overcome this and start populating earth, leading to further concentration and non-sustanence leading imbalance of bio-energy. Hence, in order to sustain this huge population of dinosaurs, the autotrophs are not in a position to support them. In this regard, nature might have decided to select the dinosaur population for mass extinction. It is also believed that the reason for presence of super sized dinosaurs during cretaceous period could be the then autotrophic plants which flourished during those periods. The autotrophic plants which were present in those days were mostly non-flowering and are fast convertor of Sun's solar energy into bio-mass, which might have sustained the dinosaurs to extent of about 165 million years.

III. Conclusion

Mass extinction of dinosaurs during cretaceous period might have occured due to tendency of nature to change the environment that could maintain a sustainable dependence system within living organism. The other reason may be to conserve the under-privileged organisms which were suppressed by dinosaurs for many years. If a species is in a dominant position, naturally they could able to suppress the lower level species for their needs and want, but it should not be over exploited, as done by the dinosaurs in the past.

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