Ecosystem Energy Changes

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DOI: https://doi.org/10.51244/IJRSI.2023.1012022

Received: 24 November 2023; Revised: 05 December 2023; Accepted: 08 December 2023; Published: 08 January 2024

ABSTRACT

In this paper energy in ecosystem was studied. Energy balance equations of ecosystem were derived. Most of the energy in the Earth's system comes from just a few sources: solar energy, gravity, radioactive decay, and the rotation of the earth. Earth is constantly changing as energy flows through the system. Earth's weather and climate are mostly driven by energy from the Sun. The Sun provides the energy that drives the water cycle on Earth. In this paper different forms of energy, specific types, using and energy conservation were studied. Environments are highly complex systems whose evolution is determined by complicated networks of positive and negative feedback loops. In this paper macroscopic and microscopic approaches to energy flow through the ecosystem have been used.

Keywords: Ecosystem, energy, environment, sources, balance.

INTRODUCTION

Solar energy drives many surface processes such as winds, currents, the hydrologic cycle, and the overall climate system.

A number of models for plant environment interactions and particularly for the utilization of energy by plant, have been developed since the 1950s. Several of these attempt to understand plant growth and water use as related to specific physiological and environmental parameters [1], [2]. These models, however, can not be applied to situations for which few data are available unless a number simplifying assumptions are used. On the regional and geographical levels, other models of a predominantly qualitative character have been suggested [3],[4]. As a consequence of this dichotomous development, attempts have been made to unify these two approaches with a view to simplifying the comprehensive models, so as to make them applicable to regional use to areas with limited data, without introducing misleading over simplifications.

In this paper energy sources and changes of ecosystem were studied.

Energy on the earth

Geologic, fossil, and ice records provide evidence of significant changes throughout Earth's history. These changes are always associated with changes in the flow of energy through the Earth's system. Both living and non-living processes have contributed to this change.

Sunlight, gravitational potential, decay of radioactive isotopes, and rotation of the Earth are the major sources of energy driving physical processes on Earth. Sunlight is a source external to Earth, while radioactive isotopes and gravitational potential, with the exception of tidal energy, are internal. Radioactive

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume X Issue XII December 2023

isotopes and gravity work together to produce geothermal energy beneath earth's surface. Earth's rotation influences the global flow of air and water. For example, unequal warming of Earth's surface and atmosphere by the Sun drives convection within the atmosphere, producing winds, and influencing ocean currents.

Water plays a major role in the storage and transfer of energy in the Earth system. The major role water plays is a result of water's prevalence, high heat capacity, and the fact that phase changes of water occur regularly on Earth [5]-[7].

Movement of matter between reservoirs is driven by Earth's internal and external sources of energy [8]-[12]. These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life. Energy drives the flow of carbon between these different reservoirs.

Greenhouse gases affect energy flow through the Earth's system. Greenhouse gases in the atmosphere, such as carbon dioxide and water vapor, are transparent to much of the incoming sunlight but not to the infrared light from the warmed surface of Earth. These gases play a major role in determining average global surface temperatures. When Earth emits the same amount of energy as it absorbs, its average temperature remains stable [13]-[16].

The effects of changes in Earth's energy system are often not immediately apparent. Responses to changes in Earth's energy system, input versus output, are often only noticeable over months, years, or even decades.

The Sun is the major source of energy for organisms and the ecosystems of which they are a part. Producers such as plants, algae, and cyanobacteria use the energy from sunlight to make organic matter from carbon dioxide and water. This establishes the beginning of energy flow through almost all food webs.

Food is a biofuel used by organisms to acquire energy for internal living processes. Food is composed of molecules that serve as fuel and building material for all organisms as energy stored in the molecules is released and used. The breakdown of food molecules enables cells to store energy in new molecules that are used to carry out the many functions of the cell and thus the organism.

Energy available to do useful work decreases as it is transferred from organism to organism. The chemical elements that make up the molecules of living things are passed through food chains and are combined and recombined in different ways. At each level in a food chain, some energy is stored in newly made chemical structures, but most are dissipated into the environment. Continual input of energy, mostly from sunlight, keeps the process going.

Energy flows through food webs in one direction, from producers to consumers and decomposers. An organism that eats lower on a food chain is more energy-efficient than one eating higher on a food chain. Eating producers is the lowest and thus most energy-efficient level at which an animal can eat.

Humans are modifying the energy balance of Earth's ecosystems at an increasing rate. The changes happen, for example, as a result of changes in agricultural and food processing technology, consumer habits, and human population size [7].

DIFFERENT FORMS OF ENERGY

Energy is a paradox: it brings us light, warmth, security, and mobility. But on the other hand, energy extraction, the burning of fossil fuels, and the unequal distribution of energy resources have wrought environmental and social problems for humanity. Energy use is at the root of climate change and many other issues. Today we are seeing the beginnings of a global shift in energy sources and energy policy toward more cooperative, sustainable use of energy. The topics around energy are relevant in all science disciplines as well as in engineering, policy, social science, and economics.

This series of web pages begin with the physics of energy and proceeds through a discussion of energy in biological systems and throughout the Earth's system. Taken together, these concepts describe energy literacy.

In our daily lives, we constantly interact with different forms of energy. Energy is contained in gasoline, cat food, and stars, and energy moves from one form to another via wind, motion, and heat. So where to begin teaching something that is both intuitively obvious yet abstract and complex? This principle helps students become familiar with some of the fundamentals of energy, much of which is based on physics. We want students to become comfortable with the concept that energy comes in many forms, can be transferred from one system to another, and can be measured. While it is difficult to define the term energy, it is not difficult to identify, describe and measure specific types of energy.

SPECIFIC TYPE OF ENERGY

Mechanical energy is the energy of mechanical systems, such as a ball rolling on a ramp, or a marble fired from a slingshot. Mechanical energy can be in three forms:

- Gravitational potential energy is the energy of an object or system due to gravitational attraction. For example, it can calculate the mechanical energy of a ball that is going to be released from a high window or the gravitational potential energy of the water in a reservoir used for hydropower.
- Kinetic energy is energy due to the motion of an object. A speeding car, a baseball lofting through the air, and a skier sliding downhill are all examples of objects with kinetic energy. Flywheels are a method of storing kinetic energy.
- Elastic potential energy is the energy stored in a stretched spring, rubber band, or other elastic material.

Thermal energy is the energy that results from the kinetic energy of molecules of a substance. A hot tea kettle has more thermal energy than a cold one. Objects that feel warm are emitting thermal energy, and the transfer of thermal energy causes temperature changes.

Radiant energy is the energy from electromagnetic radiation, such as visible light, microwaves, or X-rays.

Chemical energy is energy stored in chemical bonds. Gasoline and food are examples of compounds with chemical potential energy.

Nuclear energy is a name given to the energy that results from mass-to-energy conversion during nuclear reactions. This is a potent and plentiful source of energy because a small amount of mass can be converted into a large amount of energy as described by Einstein's famous equation . $E=mc^2$

Regardless of what form energy takes, energy has a numerical value that we can measure and assign to objects or systems. When the system undergoes some change, energy can be transformed from one type of energy to another.

ENERGY USE

Every society needs energy. But energy use is tied to many environmental and societal concerns, such as greenhouse gas emissions, mining, pipelines, fracking, and the "embedded energy" in energy infrastructure. No form of energy is free of impacts, but some forms are certainly better than others. Using less energy and using energy efficiently are straightforward ways to reduce the burden on the environment.

The amount of energy use is affected by several factors.

- Energy use can be reduced by limiting wasteful practices by eliminating unnecessary uses of energy, or by opting to use the most efficient form of energy available.
- Technological or social innovation can reduce energy consumption.
- Design of products, technology, or infrastructure can result in lower energy consumption.
- Knowledge of the amount of energy used for different processes can inform decisions about energy use.

These concepts help us understand our consumption of energy, both on an individual level and on a societal scale. Building students' knowledge of energy consumption can prompt behavioral choices and motivate students to take personal action to reduce energy use. Activities that teach this principle are often designed to have a strong take home message that connects classroom learning to one's daily life and decisions.

Misconceptions about energy use are commonplace

A persistent misconception implies that reducing energy use equates to a lower standard of living. In fact, the opposite is true in many cases. A modern, efficient car can drive farther on the same amount of fuel compared to an older car. Living nearer to school, work, and community provides many conveniences while reducing the energy needed for transportation. Eating a vegetarian-based diet has many benefits for human health. Educators will have to address the misconception that energy consumption (or even energy waste) is equated with socioeconomic success. That said, in low to middle income nations, access to energy is directly linked to the standard of living. As with many misconceptions, there is an element of truth to this idea.

There are also many folkloric misconceptions about energy use that can be addressed when teaching about energy consumption.

Quantitative skills can strengthen understanding of energy use

Students may place a disproportionate amount of emphasis on relatively small fractions of energy use. For example, while it is a good practice to unplug cell phone chargers when not in use, it saves 16 times more energy to shorten your hot shower by one minute. Similarly, students may get the impression that switching to energy-efficient light bulbs can "solve" the energy problem. By keeping scale in mind, students can appreciate the level of effort that is needed to significantly slow the growth in energy demand.

ENERGY CONSERVATION

Conservation of energy has two very different meanings. There is the physical law of conservation of energy. This law says that the total amount of energy in the universe is constant. Conserving energy is also commonly used to mean the decreased use of societal energy resources. When speaking of people conserving energy, this second meaning is always intended.

One way to manage energy resources is through conservation. Conservation includes reducing wasteful energy use, using energy for a given purpose more efficiently, making strategic choices as to sources of energy, and reducing energy use altogether.

Human demand for energy is increasing. Population growth, industrialization, and socioeconomic

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume X Issue XII December 2023

development result in increased demand for energy. Societies have choices with regard to how they respond to this increase. Each of these choices has consequences.

Earth has limited energy resources. Increasing human energy consumption places stress on the natural processes that renew some energy resources and it depletes those that cannot be renewed.

Social and technological innovation affects the amount of energy used by human society. The amount of energy society uses per capita or in total can be decreased. Decreases can happen as a result of technological or social innovation and change. Decreased use of energy does not necessarily equate to decreased quality of life. In many cases, it will be associated with increased quality of life in the form of increased economic and national security, reduced environmental risks, and monetary savings.

Behavior and design affect the amount of energy used by human society. There are actions individuals and society can take to conserve energy. These actions might come in the form of changes in behavior or in changes to the design of technology and infrastructure. Some of these actions have more impact than others.

Products and services carry with them embedded energy. The energy needed for the entire life cycle of a product or service is called the "embedded" or "embodied" energy. An accounting of the embedded energy in a product or service, along with knowledge of the source(s) of the energy, is essential when calculating the amount of energy used and in assessing impacts and consequences.

Amount of energy used can be calculated and monitored. An individual, organization, or government can monitor, measure, and control energy use in many ways. Understanding utility costs, knowing where consumer goods and food come from, and understanding energy efficiency as it relates to home, work, and transportation are essential to this process.

ENERGY BALANCE EQUATIONS OF ECOSYSTEM

The disposition of radiant energy at the surface of the earth is of prime importance for understanding soil-water balances and the related chemical transport and transformation processes. A formalized transcription of the energetic relationships yields the following form of the energy balance equation:

$$R_n+H_s+H_a+r_{ET}=0 \qquad (1)$$

In this equation, which summarizes the solar energy cascade with its numerous regulation and transformation components, any form of energy that is flowing toward the surface is considered positive and any form that is moving away from it is considered negative. R_n is the net radiation flux, H_S is the heat flow in soil at the surface, H_a is the sensible heat transfer through air at the surface, and r_{ET} is the transfer rate of latent heat due to evapotranspiration.

R_n is net energy and can be defined:

$$R_n = ES(1-\alpha) + R_c - \varepsilon\sigma T^4 \qquad (2)$$

Solar radiation is defined as:

$$\rho c_p\left(\frac{\partial T}{\partial t} + v_x\frac{\partial T}{\partial x} + v_y\frac{\partial T}{\partial y} + v_z\frac{\partial T}{\partial z} + \sum_{i=1}^{n}\frac{\partial (v_i T)}{\partial \xi_i}\right) - \lambda\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right) + (S_r) = 0 \qquad (3)$$

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume X Issue XII December 2023

R_c the long-wave counter, radiation counter of the lower atmosphere is:

$$\rho c_p(\frac{\partial T}{\partial t}+v_x\frac{\partial T}{\partial x}+v_y\frac{\partial T}{\partial y}+v_z\frac{\partial T}{\partial z}+\sum_{i=1}^{n}\frac{\partial(v_iT)}{\partial\xi_i})+(S_r)=0 \quad (4)$$

if diffusion neglected.

H_a the sensible heat transfer through air at the surface

$$\frac{\partial Q}{\partial t}=\rho c_p(\frac{\partial T}{\partial t}+v_x\frac{\partial T}{\partial x}+v_y\frac{\partial T}{\partial y}+v_z\frac{\partial T}{\partial z})=\lambda(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}) \quad (5)$$

H_S the heat flow in soil at the surface:

$$\frac{\partial Q}{\partial t}=\rho c_p(\frac{\partial T}{\partial t})=\lambda(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}) \quad (6)$$

If neglected changes in y and z direction is obtained:

$$\frac{\partial Q}{\partial t}=\rho c_p(\frac{\partial T}{\partial t})=\lambda(\frac{\partial^2 T}{\partial x^2}) \quad (7)$$

and

$$\frac{\partial T}{\partial t}=\frac{\lambda}{\rho c_p}(\frac{\partial^2 T}{\partial x^2}) \quad (8)$$

r_{ET} the transfer rate of latent heat due to evapotranspiration is:

$$c_{P,}\rho\ (\frac{\partial T}{\partial t}+v_x\frac{\partial T}{\partial x}+v_y\frac{\partial T}{\partial y}+v_z\frac{\partial T}{\partial z}+\sum_{i=1}^{n}\frac{\partial(v_iT)}{\partial\xi_i})-$$
$$\lambda\ (\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2})+(\Delta H\ \ )+(\Delta H)_m=0 \quad (9)$$

Conventionally, all terms are expressed in joules per minute and square centimeters, 4.19cm^{-2} min $^{-1}$equals ca. of water depth evaporated per hour.

The Earth's surface receives short- wave and long- wave counter radiation from the atmosphere, while itself emitting long-wave radiation. Whereas photochemical reactions are controlled mostly by short- wave radiation, the diurnal variability of surface temperature and the related energy fluxes are very much under the influence of long-wave radiation. Thus, the net radiation flux R_n may be derived from the short and long-wave radiation balances as shown in (2), where the solar radiation ES involves direct beam radiation ES_S and diffuse radiation ES_D, each term comprising short-wave and solar long-wave components R_c is the long-wave radiation counter of the lower atmosphere, $\varepsilon\sigma T^4$ the long-wave radiation from the Earth's surface (Stefan-Bolzmann radiation), α the reflectivity.

The rate at which heat is transferred down wards into the soil and subsurface substrate H_s is directly related to the nature and efficiency of the distribution mechanisms. In solids, heat is redistributed by conduction, and the flow rate depends on thermal conductivity, λ. Units are watts per meter per degree, $Wm^{-1^\circ}C^{-1}$ or joules per centimeter per second per degree Celsius, $Jcm^{-1}s^{-1^\circ}C^{-1}$. Under steady state conditions, the flow of heat $\partial Q/\partial t$ is related to the temperature gradient $\partial T/\partial x$ and the thermal conductivity by

$$H_S = \frac{\partial Q}{\partial t} = \lambda \frac{\partial T}{\partial x} \qquad (10)$$

A major problem in soils is that steady state conditions are rarely achieved and thermal conductivity is a complicated function of granulometry, mineralogical composition, compaction, and water content. The conventional determination of thermal conductivity is consequently fairly difficult. An alternative parameter, thermal diffusivity, is used, which is given by $\lambda / c_p \rho$, where c denotes the specific heat and ρ the density, units are square meters per second. For homogenous medium, thermal diffusivity defines the rate at which temperature changes $\partial T/\partial t$ take place as in (8).

Where T temperature, (ΔH) chemical reaction heat, $(\Delta H)_m$ interphase heat transfer, x, y, z space coordinate, v geometrical velocity, S_r some heat generation, ξ attribute of interest and t is time.

The magnitude of the heat flow into the air at the surface can be obtained by a difference when the other components of the energy balance in equation (1) are measured, or it can be determined directly. Among the latter approaches, two methods, the aerodynamic method Sverdrup–Albrecht method merit particular attention.

The *aerodynamic methods* is based on very precise determinations of the vertical temperature and wind profiles, and involves a horizontal homogeneity of the surface over considerable distances in the luff of the measuring station.

The *Sverdrup-Albrecht method* determines either and as components of the energy balance in equation (11):

$$H_a = \frac{H_a}{r_{ET}}(R_n - H_s)(1 + \frac{H_a}{r_{ET}})^{-1} \qquad (11)$$

The ratio H_a / RT (Bowen ratio) can be estimated from measurements of the vertical gradients of temperature $\partial T/\partial z$ and vapor pressure $\Delta e / \Delta z$ above the surface.

The latent heat flux can be estimated as a result of vaporization or condensation of water. Consequently, five general methods are used to evaluate the water vapor flux caused by evaportranspiration.

$$r_{ET} = (R_n - H_s)(1 + \frac{H_a}{r_{ET}}) \qquad (12)$$

Thornthwaite and Holzman [3] suggested

$$r_{ET} = \frac{\rho k(U_2 - U_1)(q_1 - q_2)}{\{\ln(z'_1 / z'_2)]^2} \qquad (13)$$

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume X Issue XII December 2023

where q average water vapor, Pa, ρ, g/cm^3 the air density, U, cm/s the average wind speed, z' the average elevation above surface, cm and k von Karman's constant, 0.4.

A continuous record of water vapor convention by means of eddy-correlation techniques as described by Dyer [16] yields estimates of r_{ET} by

$$r_{ET} = \frac{1}{t}\int_0^t \rho wq dt \qquad (14)$$

where w the momentary vertical wind speed, and q the instantaneous value of water vapor concentration. The problem of measuring r_{ET} as the time average of the vertical flux of water vapor thus becomes one of designing instrumentation capable of measuring the turbulent air motion and structure of q. This involves equipment whose response time is sufficiently short to take account of all frequencies in the turbulent spectrum contributing significantly to the flux. This requirement depends on both the height of measurement and the ability of the air, which means, in general terms, that the sensing elements should respond adequately to signals with a period of $1s$.

If all terms of energy budget are known except the flux due to evaporation (or evaportan spiration), the latter can be obtained by a difference. Finally the latent heat flux can be found by direct measurement, i.e., by means of weighing lysimeters on the local scale or as the difference term of the water budget of a drainage system on the regional scale.

Notation

- c -denotes the specific heat, $Jgr^{-1}step.^{-1}$

H_a - the sensible heat transfer through air at the surface , $Jcm^{-2}\min^{-1}$

H_S - the heat flow in soil at the surface, $Jcm^{-2}\min^{-1}$

r_{ET} -the transfer rate of latent heat due to evapotranspiration, $Jcm^{-2}\min^{-1}$

R_n - the net radiation flux, $Jcm^{-2}\min^{-1}$

q - average water vapor

S_r - generation heat, $Jcm^{-2}\min^{-1}$

T -temperature, $step.$

U - the average wind speed, cm/s

v - geometrical velocity, cm/s

w - momentary vertical wind speed, cm/s ,

z' - average elevation above surface, cm

x, y, z space coordinate

Greek symbols

α - reflectivity

(ΔH) -latent heat of chemical reaction, $Jcm^{-2}\min^{-1}$

$(\Delta H)_m$ - interphase heat exchange, $Jcm^{-2}\min^{-1}$

λ - thermal conductivity, $Jcm^{-2}step.^{-1}$

ξ - attribute of interest

ρ - density, g/cm^3

CONCLUSION

In this paper energy balance equations in ecosystem were derived. Ecosystems are affected by changes in the availability of energy and matter. The amount and kind of energy and matter available constrain the distribution and abundance of organisms in an ecosystem and the ability of the ecosystem to recycle materials.

Macroscopic and microscopic levels of description to energy flow through the ecosystem were applied. Entropy analysis was not taken account.

Humans are part of Earth's ecosystems and influence energy flow through these systems. Energy's influence on human society is explored from the point of view of different sources of energy, how it use energy, how it make decisions about energy, and the society-wide impacts of energy use.

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