Environmental Entomology (Ent-703) Credit Hours 2(2-0)

Lecture # 7&8 Delivered by Dr. Hassan Yasoob

Topic- Biological Responses to Pollutants and Biogeochemical Cycles; Insects as Indicators of levels of Pollution

What are biogeochemical cycles and what do they include?

Biogeochemical Cycle

Some of the major biogeochemical cycles are as follows: (1) **Water Cycle** or **Hydrologic Cycle** (2) **Carbon-Cycle** (3) **Nitrogen Cycle** (4) **Oxygen Cycle**. The producers of an ecosystem take up several basic inorganic nutrients from their non-living environment. These materials get transformed into the bio mass of the producers.

In ecology and Earth science, a **biogeochemical cycle** or **substance turnover** or **cycling of substances** is a pathway by which a chemical substance moves through biotic (biosphere) and abiotic (lithosphere, atmosphere, and hydrosphere) compartments of Earth. There are biogeochemical cycles for the chemical elements calcium, carbon, hydrogen, mercury, nitrogen, oxygen, phosphorus, selenium, and sulfur; molecular cycles for water and silica; macroscopic cycles such as the rock cycle; as well as human-induced cycles for synthetic compounds such as polychlorinated biphenyl (PCB). In some cycles there are *reservoirs* where a substance remains for a long period of time.

Ecological systems (ecosystems) have many biogeochemical cycles operating as a part of the system, for example the water cycle, the carbon cycle, the nitrogen cycle, etc. All chemical elements occurring in organisms are part of biogeochemical cycles. In addition to being a part of living organisms, these chemical elements also cycle through abiotic factors of ecosystems such as water (hydrosphere), land (lithosphere), and/or the air (atmosphere).

The living factors of the planet can be referred to collectively as the biosphere. All the nutrients—such as carbon, nitrogen, oxygen, phosphorus, and sulfur—used in ecosystems by living organisms are a part of a *closed system*; therefore, these chemicals are recycled instead of being lost and replenished constantly such as in an open system.

The flow of energy in an ecosystem is an *open system*; the sun constantly gives the planet energy in the form of light while it is eventually used and lost in the form of heat throughout the trophic levels of a food web. Carbon is used to make carbohydrates, fats, and proteins, the major sources of food energy. These compounds are oxidized to release carbon dioxide, which can be captured by plants to make organic compounds. The chemical reaction is powered by the light energy of the sun.

Sunlight is required to combine carbon with hydrogen and oxygen into an energy source, but ecosystems in the deep sea, where no sunlight can penetrate, obtain energy from sulfur. Hydrogen sulfide near hydrothermal vents can be utilized by organisms such as the giant tube worm. In the sulfur cycle, sulfur can be forever recycled as a source of energy. Energy can be released through the oxidation and reduction of sulfur compounds (e.g., oxidizing elemental sulfur to sulfite and then to sulfate).

Although the Earth constantly receives energy from the sun, its chemical composition is essentially fixed, as additional matter is only occasionally added by meteorites. Because this chemical composition is not replenished like energy, all processes that depend on these chemicals must be recycled. These cycles include both the living biosphere and the nonliving lithosphere, atmosphere, and hydrosphere.

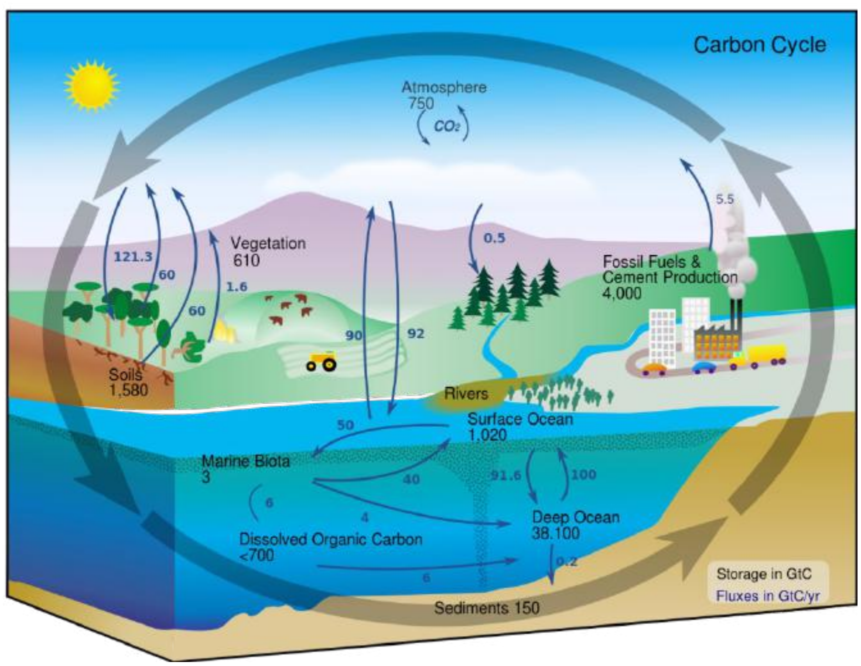
What is the role of insects in carbon cycling?

insects play an important part in the **carbon cycle** because they help to break down waste and decay, allowing it to be transported to the next stage in the **carbon cycle**. For example, termites break down organic debris in rainforests, allowing it to be added to the soil and used by plants, which are **carbon** reservoirs. How do dung beetles play a role in the carbon cycle?

In the carbon cycle, what role do dung beetles play? ... **Dung beetles** are invertebrate scavengers, the job they **do** is burying **dung**. Their grubs find food within the **dung** and it protects them. The fungus in the soil digests the cellulose in the **dung** and provides the grubs with an addition to their diet.

What would happen to the carbon cycle if deforestation occurred?

Deforestation has an effect on the **Carbon Cycle** also known as the Greenhouse gas effect and global warming. Trees and forest balance the amount of **Carbon** in the atmosphere through the process of photosynthesis in which plants make their own food with **carbon** dioxide. ... This excess heat warms the earth.



Carbon cycle

Insect population responses to environmental stress and pollutants

Insects and other related arthropods make up about 90% of all plant and animal species in the world. They are vital to the functioning of the ecosystem and biosphere, and neither of these systems can operate effectively without insect interactions. Because of their major ecological and economic roles in nature and society, the beneficial and pest activities of insects need to be clearly understood. Insect populations are being stressed directly by the action of temperature, moisture, and a wide array of chemical Ö öpollutants (pesticides, fertilizers, air pollutants, and numerous other chemicals) that are dispersed through air, water, and soil. Insects are affected by this same group of stresses indirectly, through their food plants, parasites, and predators. Depending on the species and the particular stress affecting it, insect populations respond by increasing or decreasing in numbers. The responses of insect populations to various direct and indirect environmental stresses and chemical pollutants are assessed. Some insect populations increase, while others decline. The responses were determined by the particular environmental stress, the insect species, and the stage at which they were exposed to the stress.*Key words*: insects, environment, pollutants, stress, water, herbicides.

Topic # 8: Insects as Indicators of levels of Pollution

Several aquatic insects groups can be used as aquatic environment bioindicators (Table 2). Odonata (dragonflies) species are very sensitive to changes caused to their habitat, especially lakes and flooded drainage areas (CORBET, 1980). Hamilton and Saether (1971) and Hardersen (2000) reported the potential of aquatic insects as indicators of water quality. Several other species of the families Gyrinidae, Dytiscidae, Hydrophilidae (Coleoptera), Notonectidae, Veliidae (Heteroptera) and Plecoptera and Ephemeroptera Orders have high adaptive capacity, colonizing most of the environments and occurring throughout the year, reflecting ecological and geographical changes, and hence their conservation status. The tolerance of aquatic organisms to heavy metals has been explained by the metallothioneins (MTs) formation in many aquatic organisms. If the presence of MTs is a measure of metal tolerance, the measurement of MTs could provide clues about the tolerance in this organisms and possible toxic agents responsible for environmental stress (BISTHOVEN et al., 1998). However, insects are less used as pollution bioindicators by metals, although species of the genus Halobates are suitable for bioindication of cadmium and mercury (NUMMELIN et al., 2007). Land insects are good bioindicators in various types of environmental change (Table 2). The Order Coleoptera represents approximately 20% of the total diversity of arthropods and plays roles in maintaining soil quality, population regulation of other invertebrates and energy flow, and contributes to the physical and chemistry soil formation (CARLTON and ROBISON, 1998). Nummelin and Hanski (1989), Nestel et al. (1993), Louzada and Lopes (1997) and Davis (2000) confirm beetles species (Coleoptera: Scarabaeidae) have a high potential as environmental indicators in forest area or agricultural crops. Beetles from Order Coleoptera and Family Carabidae are important predators. They participate of biological control, biological monitoring of pollution from oil, sulfur, herbicides, CO_2, insecticides and radioactive phosphorus. The moths and butterflies (Lepidoptera), besides having basic requirements, have ecological faithfulness in temperate and tropical regions and are very sensitive to changes in the environment (GILBERT, 1984; ANDRADE, 1998). The habitat mosaic maintenance that includes primary forests and other changed areas with different change levels was

the strategy suggested by Wood and Gillman (1998) to protect Lepidoptera diversity in natural environment management (WOOD and GILLMAN, 1998).

Some Lepidopteran groups are used as environmental pollution indicators

by heavy metals and carbon dioxide (CO_2 concentration) in locations close to industrial areas and even within urban areas. Presence and consequences of copper, iron, nickel, cadmium, sulfuric acid ions and other substances used in fertilizers were studied with pupae of different Geometridae and Noctuidae species (HELIÖVAARA and VÄISÄNEN, 1990), Eriocraniidae populations (KORICHEVA and HAUKIOJA, 1992), cycle duration and newly hatched larval mortality rate from butterflies (Family Nymphalidae), which feed on plants subjected to high CO2 concentrations (FAJER et al., 1989). Collembola are primitive insects that influence soil fertility through microbial activity stimulation, the fungi spore distribution and inhibit fungi and bacteria action causing diseases in plants (SAUTER and SANTOS, 1991; RUSEK, 1998). They are very sensitive to changes in the soil and diversity reduction can show us pollution by heavy metals, pesticides in agricultural soils and soil water acidification by organic pollutants and waste (RUSEK, 1998). Ants are used as soil quality bioindicators and have a key role in the recovery of degraded and reforested areas (MEJER, 1984). This group, which is very sensitive to human impact, could be used as environmental indicators in different ecosystems (FOLGARAIT, 1998; PECK et al., 1998). Depending on the degree of the environmental change, many expert species are extinct of the site, encouraging the establishment of dominant, aggressive and generalist species, which can be used as indicators of disturbed habitats (READ, 1996). The ants presented a strong resistance to pollutants (radioactive and industrial pollutants) that may be because only about 10% of individuals fall outside the nest and exposed to the harmful pollution effects (PETAL, 1978). Peck et al. (1998) suggest that some ant groups have potential as biological indicators of soil conditions, crop management and assessment systems for plantations in agroecosystems. The impact of ants in soil is demonstrated by leaf cutting ones in the tropics, where they are the most important agent of change in the soil, contributing to improving physical and chemical quality (CHERRET, 1989). Order Diptera is a very heterogeneous group and there are some restrictions on its use as bioindicator because of the lack of ecological knowledge of many groups of flies. However, some flies species are considered good environmental change bioindicators. Bartosova et al. (1997) showed the potential of species from the Family Sarcophagidae as environmental pollution indicators by heavy metals, asbestos fibers and waste chemicals. However, due to variability in the flies' sensitivity to insecticides and herbicides, Frouz (1999) recommends that one must be careful when using some species of flies as chemical indicators of contaminated soil. Family Syrphidae, one of the largest families of Diptera, has wide distribution, well known taxonomy and its larvae require different environmental conditions, which makes these flies' good bioindicators. Due to environmental requirements of their larvae, these insects are particularly affected by the landscaping diversity reduction (SOMMAGGIO, 1999). Most of the research on pollinators as bioindicators have been on population level and have focused mainly on bees. The pollinator strength and its population size are generally considered the most important features for plant reproduction, especially to the agricultural crops (KEVAN, 1999). Pollinators, especially honeybees (Apis mellifera), are considered reliable biological indicators because they show environment chemical impairment due to high mortality rate and intercept particles suspended in air or flowers. These substances can then be detected using methods of analysis (GHINI et al., 2004).