

Ethno-ecological Introspection into *Bhagawatgeeta*:

2. Principles and Components of the Ecosystem

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ABSTRACT The discourse in the *Geeta* reveals many aspects of Ecology which are amenable with modern science. The ancient Indian thoughts on Ecological factors; Flow of energy in Ecosystem; Nature's hydrological cycle; Ecological niche and Socio-ecological pyramids are discussed in this paper.

INTRODUCTION

Every aspect of life is influenced by environment and the activities of organisms affect their environment. This inter-relationship between biotic and abiotic components as well as the interactions between the individuals of the biotic components is called as the science of 'Ecology'. The communities and their environment form a functional unit called 'Ecosystem'. Thus ecology is the science of ecosystems, the totality of reciprocal interactions between living organisms and their physical environment.

The word ecology (*Oekologie*) traces its origin in 1885, derived from Greek words *Oikos* (meaning the dwelling place/ home) and *logos* (the discourse / study) named by H. Reiter, a Zoologist. There have been many attempts to define the discipline ecology since the later part of 19th century and 20th century. The latest definition of Krebs (1985) in simple modern comprehensive way is: "Ecology is the scientific study of the interactions that determine the distribution and abundance of organisms". In the eastern world during the post Vedic period, Manu is the pioneer to establish the importance of ecological niche (discussed later), has used the words "Pruthak Sansthaascha nirmamay" [different (living) conditions for different created beings was established- *Manusmriti* 1/21; Bühler 1886] which refers to the ecosystem of modern ecology. Many more ecological aspects in *Manusmriti* such as: Ecological factors; Hydrological cycle; Ecological niche; Food chain; Concept of ecological indicator; Consciousness for pollution and contamination and the Scientific basis to conserve the biodiversity are noteworthy (Dash and Padhy 1998ab; Mohapatra et al.

2001; Padhy et al. 1997ab). Above all, the formulation of environmental laws by Manu is very significant (Padhy et al. 2006).

The other Sanskrit epics like *Vrikshaayurveda* (by Sarangadhar), *Vrikshaayurveda* (by Parasara, 250-120 B.C), *Brihataaranyaka Upanishad*, *Brihat Samhitaa* (by Varaha Mihir, 500 A.D), *Upasakra* (by Shankar Mishra), *Suddarssana Samuchaya*, *Kiranaavali* (by Uddayana), *Charak Samhitaa* (by Charak), *Sussruta Samhitaa* (by Sussruta) and *Arthashastra* (by Koutalya) along with the Vedas record many ecological concepts and various aspects of biological science realized by the ancient seers which supports their scientific attainments (Sivarajan 1991). In the present contest an attempt is made to explore the principles of ecosystem revealed by Lord Sri Krishna in *Bhagawatgeeta*, in continuation to the previous work and the methods of study are as reported earlier (Padhy 2013).

ECOLOGICAL FACTORS

Modern environmental science has broadly classified the ecological factors into two categories: abiotic and biotic. The abiotic factors are again divided into three: 1. Climatic factors (light, temperature, rainfall, humidity and atmospheric gases), 2. Topographic or physiographic factors (altitude, direction of mountains, steepness and exposure of slopes related with the physical geography of the earth), and 3. Edaphic factors (deal with soil formation, its physical and chemical properties). The biotic factors include all kinds of interactions between the different forms of life, that is, plants, animals and microorganisms. In a natural condition the life of an organ-

ism is affected by the sum total of all ecological factors; not by any individual factor. From physical point of view, the body of an organism and its activities are a combination and interaction of different elements of the environment. As the physical environment affects the life of an organism, similarly the organisms along with their own interactions, affect the physical environment. This reciprocal interaction between the organism and the environment is responsible for the development, evolution and expansion of biodiversity on this earth. In the seventh chapter of *Geetaa*, Sri Krishna says:

- ♦ “Earth, water, fire, air, ether, mind, intellect and egoism; thus is my Prakriti divided eight fold. This is my lower Prakriti (*Aparaa*), but different from it, know, O mighty-armed, my higher Prakriti (*Paraa*)-the life element (*Jiva*) by which this universe is upheld (7/4,5)”.

Division of the *Prakriti* (Nature) into *Paraa* (living) and *Aparaa* (non-living) is the first step in the *Geetaa* towards the ancient ecological knowledge. Out of eight elements of *Aparaa Prakriti* the first five are Earth (*Kshiti*), Water (*Aapa*), Fire (*Tejas*), Air (*Vaayu*) and Ether (*Aakaasa*) constitute the *Panchamahaabhoota*, a basic thought of the ancient Indians on environmental science. In fact, all manifestations in the phenomenal world, which are recognized as ecological factors in modern science such as (1) climatic (2) physiographic and (3) edaphic factors are the different modifications of the *Mahaabhootas* and nothing new. But ether, the principle of vacuity, the prime among the *Mahaabhootas* in increasing tangibility order (that is, *Aakaasa-Vaayu-Tejas-Aapa-Kshiti*) is not emphasized as an ecological factor in modern sci-

ence, even though space and time are two great concepts in Einstein’s theory of relativity. All these support the view, that ancient Indians were the pioneers of the comprehension and scientific perception of ecological factors as *Mahaabhootas* (Mohapatra et al. 2001). The Vedic view on two *Mahaabhootas*: *Tejas* and *Aapa* is presented in Box-1.

Box-1

Rig Veda 1.3.1-4

The *Ashwins*, such as fire and water, are a complementary pair, astir with vital energy
They are indispensable to and inseparable from all forms of productive activity, particularly for rapid round growth, understand them and use them for peaceful purposes.

× × × ×

The *Ashwins*-remember, are extremely beneficial in diverse forms where accelerated production is concerned.

Proclaim to the world the vast potentialities of these forces, so that more and more people derive benefit from them in the larger interest of humanity.

× × × ×

The *Ashwins* together have powers and potentialities beyond human comprehension.
And have tremendous impact on the birth and growth of every living being, in fact of every living organism of the cosmos.

× × × ×

O *Indra*, giver of radiant rays and source of subtle and immanent powers.
All the objects of cosmic creation, inanimate as well as animate, are there because of your grace and benediction.

Transcreation: Vidyalkar (1974)
Ashwins: Twin *Devataas*-Ecological Powers.
Indra: The king of *Devataas*-The authority of the nature’s hydrological cycle.

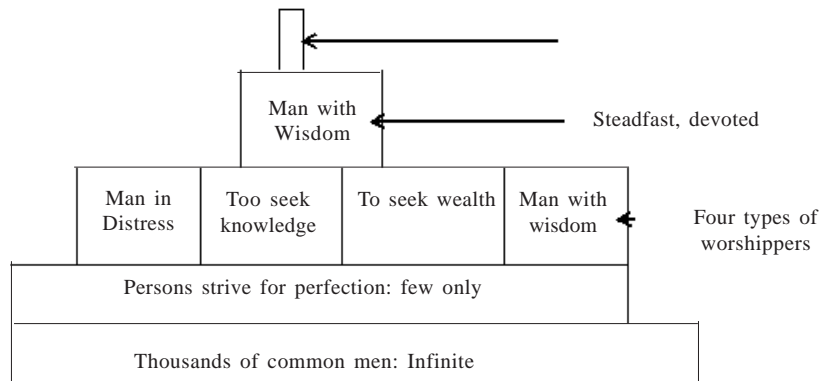


Fig. 1. The pyramid model to focus the virtuous men in the society (Figure-not upto scale)

The later three factors of *Aparaa Prakriti* are mind (*Maanas*), intellect (*Buddhi*) and egoism (*Ahamkaara*). These are more metaphysical than physical in their existence. In the absence of *Paraa Prakriti* (Life) these three behave as if they do not exist. The *Maanas* is the mind in real sense what a common man (organism) understands. It is the unit of performing mental process. It has the rational directing power behind all actions. It is the base of desire and associated with the five abstract knowing senses (*Jnaanendriyas*: *Ssrotra*-power to hear, *Twak*-power to feel, *Chakshu*-power to see, *Rasana*-power to taste and *Ghraana*-power to smell) and five abstract working senses (*Karmendriyas*: *Baak*-power to express, *Upastha*-power to procreate, *Paayu*-power to excrete, *Paani*-power to grasp and *Paada*-power to move). *Maanas* is the instrumental through which thoughts enter from the subjects and it constantly vacillates between objects.

The *Buddhi* is the seat of intelligence or the initiating capacity of the individual. It is the capacity of determination. It is the basis for knowing, willing, feeling and resolving. It dwells upon a thought that rises in a mind (*Maanas*). It is analytic in nature.

The *Ahamkaara* is the individuating or arrogating principle. It is responsible for the position or identity of an individual. It accounts for the mental attitude of 'I know', 'I exist', 'I have', etc. It is a self-conscious principle. It relates to all experiences that had by the mind and intelligence. It has the function of accepting or rejecting the demands or wishes made by the impulses, for its benefit as a whole.

The *Maanas*, *Buddhi* and *Ahamkaara* constitute the *Chitta* as a whole. The *Chitta* is defined as the organized totality of conscious experience. Its distinguishing feature is awareness and capacity to know its environment. The *Chitta* is the great environmental factor that plays an essential role in human ecology (Padhy 2006). *In toto*, the *Maanas* perceives and presents, the *Ahamkaara*-arrogates and the *Buddhi* discriminates, decides and resolves which finally leads to rise of an action (*Karma*). The mental vibrations indulge some one to execute a *Karma* (resultant action); an ecological basis of performance of right and wrong. These three environmental factors are analysed very minutely by ancient Indians, which are not accepted and as-

sociated as ecological factors in the modern science. Sri Krishna tells Arjuna,

- ♦ "Know that all beings have evolved from this two fold Prakriti (*Paraa* and *Aparaa*), and that I am the source of the entire creation, and into me again it disappears (7/6)". This rightly reflects on the interactions between the organism and the environment of modern ecology.

FLOW OF ENERGY IN ECOSYSTEM

The sun is the source of energy for our solar system. The surface temperature of the sun is 6000°C and at the centre it is fifteen million degree centigrade. The radiant energy from the sun is released in the form of electromagnetic waves due to transmutation of Hydrogen to Helium. Out of the total solar radiation, 1/50 millionth fraction reaches the earth's atmosphere every time. About 34% of this energy is reflected back and 10% held by Ozone layer, water vapour and other atmospheric gases. The rest 56% reaches the earth's surface, out of which 1 to 5% is used by green plants for photosynthesis and the other part is absorbed as heat by ground vegetation and water.

Lord Sri Krishna elaborates the importance of Sun as the source of energy in the *Geetaa* in different *Sslokas* (7/8; 9/19; 10/21; 13/33; 15/12). In the 15th chapter He says:

- ♦ The light which residing in the Sun illumines the whole world, that which is in the moon and in the fire-know that light to be Mine (15/12).
- ♦ Entering the earth I support all beings by My energy; and having become the sapid moon I nourish all herbs (15/13).

When the light energy falls on the green surface of plants, a part of it is transformed into chemical energy by the process of photosynthesis, which is stored in various organic products of the plants. The plant world is known as producers represent the first trophic level in an ecosystem. Those who obtain energy from other living organisms are called consumers. The herbivores consume the plants as food, represent the second trophic level. Further herbivores are consumed by primary carnivores represent the third trophic level and the top carnivores represent the last level. The micro-organisms obtain energy from dead organisms and other putrefaction sources are called decomposers,

which are associated with every trophic level. Virtually all living organisms depend upon the green plants for their energy; the top resource is the Sun. Thus, the efficiency of plants (*Geetaa*: I nourish all herbs) in capturing solar energy sets the energy flow and biological activity in a community. Energy in the form of food moves from one trophic level to another through the food chain. The food chain may be defined as the transfer of energy and nutrients through a succession of organisms by the repeated process of eating and being eaten. The Lord has rightly uttered in the *Geetaa*: “Entering the earth I support all beings by my energy”. The energy that is captured by the autotrophs does not revert back to the previous level. Thus the flow of energy is unidirectional with a progressive decrease in energy level at each trophic level. Due to the one-way flow of energy; the system would collapse if the primary source, the Sun, were cut off.

The *Geetaa* says:

- ♦ “God is the radiance of moon and sun” (7/8)
- ♦ “He is the brilliance in fire” (7/9)
- ♦ “He radiates heat as the sun” (9/19)
- ♦ “He is the radiant Sun among the luminaries” (10/21)
- ♦ “He is the one Sun illumines this entire universe” (13/33)

Life on earth thrives by converting light and heat of the sun into sentient energy (*Geetaa*: I am the life in all beings; 7/9). The energy in moon, fire and as well conserved by the earth in the form of coal and petrol are indirectly from the Sun’s source. Even the electric energy, which man gets by revolving the turbine with the flow of water, is dependent on the solar energy that triggers the nature’s hydrological cycle (*Geetaa* 9/19).

Every living organism picks up its food from the nature’s food chain. The food being digested, finally enters into the body cells. The energy that contains within the final digested product (that is, glucose) is not released inside the cell at once. It is released slowly, in a stepwise series of reactions controlled by enzymes. The series of reactions in the cell leading to the synthesis or breakdown of organic compounds is referred as metabolic pathway. The potential and stored energy of one compound (glucose) is released and utilized, in a most efficient manner, to drive the synthesis of other compounds. Both the

energy-yielding and energy-consuming reactions occur within the living cell. The nature has provided the cell with a means of temporary energy storage molecule known as Adenosine Triphosphate (ATP). Thus, the energy released by the breakdown of compounds such as carbohydrate, lipids, proteins, etc. is immediately utilized in the synthesis of ATP. The ATP energy is used to drive other synthetic reactions in the cell as well as the mechanical activities of the organism. The respiration and the various metabolic pathways of a cell that participate in the breakdown of food and release of energy (ATP) conduct the oxidation and reduction reactions several times. Oxidation refers to the removal of electrons (or Hydrogen) from a compound and reduction refers to the addition of electron (or Hydrogen) to a compound. *Bhagawaan Sri Krishna* says:

- ♦ Abiding in the body of living beings as *vaisvaanara* (the fire lodged), associated with *Praana* and *Apaana*, I digest the four kinds of food (15/14).

That energy is known as *Vaisvaanara* (*Agni*-fire) which remains in the bodies of beings as warmth and aids to the digestion of food. This energy is also known as *Jatharaagni*, the gastric fire. It is tended by the breathing that is going on incessantly in a living organism. The *Praana* refers to oxygen available through the process of respiration. *Apaana* is the hydrogen associated with the *Praana*. The *Geetaa* has used the word *Praanaapaanasamaayuktah* which means the unification of *Praana* with *Apaana*, refers to the oxidation-reduction reactions of the metabolic system. The *Praana* and *Apaana* (oxidation and reduction process) being associated with the *Vaisvaanara Agni* (digestion procedure) digest the four kinds of food ingested through the processes-masticating, sucking, licking and swallowing. *Praana* (O_2) and *Apaana* (H) Join to form water (*Jala*) molecule (H_2O) one of the end products of metabolism. The final release of ATP and its biological utility is the end point of the flow of energy in an ecosystem.

NATURE’S HYDROLOGICAL CYCLE

Interchange of water between atmosphere land and sea, and between living organisms and their environment is accomplished through wa-

ter cycle. This cyclic movement of water is known as Nature's Hydrological Cycle involves evaporation, transpiration, cloud formation and precipitation. Water atmosphere reaches the earth surface through precipitation (such as rain, dew, frost, sleet, snow, hail, etc.) and from the earth surface it reaches the atmosphere through evaporation and transpiration.

The movement of water in an ecosystem is fundamental to understand the nutrient cycle of the nature. Nearly 30 to 40 elements are required for the proper growth and development of living organisms. They are macronutrients (N, P, K, Ca, Mg, S, etc.) and Micronutrients (Cu, Zn, Mn, Fe, Bo, Mo, Co, etc.) which flow from abiotic sources to biotic components and back to the non-living systems again in a more or less cyclic manner. These are known as bio-geo-chemical cycles, which constantly help the different elements to be reused. In addition to hydrological cycle; the gaseous cycles (oxygen cycle, carbon cycle, nitrogen cycle) and sedimentary cycles (phosphorous cycle, sulphur cycle and similar cycles for other elements) run in the nature. As the 'flywheel' in a machinery network controls the movement of other wheels, similarly the hydrological cycle controls the movement of other biogeochemical cycles. In the *Geetaa* the importance of the hydrological cycle is elaborated as follows:

- ♦ All beings are evolved from food; production of food is dependent on rain; rain comes from sacrifice (*Yajnya*), and sacrifice is rooted in prescribed action (*Karma*) (3/14).

The actions performed by a system are called *Yajnya* (sacrifice). From scientific point of view the conversion of the earth's surface water to vapour by sunlight, transpiration of water by plants sucking from the deep soil along with minerals, movement of water and nutrients in the food chain from trophic level to trophic level, decomposition and transformation of waste material and dead remains by micro-organisms, exchange of gases during respiration and photosynthesis, formation of clouds in the high sky followed by precipitation; are all the activities of nature occur like a *Yajnya* with the involvement of the biotic and abiotic components of the environment. It is rightly mentioned by Lord Sri Krishna that sacrifice is rooted in prescribed action and from sacrifice rain comes (along with

other bio-geochemical cycles) which causes the production of food and sustenance of life on the earth.

Sri Krishna again says:

- ♦ I radiate heat as the Sun, and hold back as well as send forth showers, Arjuna. I am immortality as well as death; even so. I am being and non-being both (9/19)

In the above *Ssloka*, Sri Krishna has added the birth and death cycle of beings, an additional cycle (not realized by modern science) to the biogeochemical cycles of nature. The statement "He is the being and non-being", scientifically indicates to the co-ordinated relationship between the biotic and abiotic components of an ecosystem, through the hydrological and biogeochemical cycles.

ECOLOGICAL NICHE

Ecological niche refers to the ecological address of an organism. The dictionary meaning of niche is a place, employment and activity for which a person is best fitted. Ecological niche is a more inclusive term that involves: 1. physical space occupied by an organism, 2. its functional role in the community and 3. its position in environmental gradients of temperature, moisture, pH, soil and other conditions of existence. The idea of niche was first projected in *Manusmruti* (Mohapatra et al. 2001) says:

- ♦ But in the beginning He (God) assigned several names, action and condition to all created beings even according to the words of the Veda (Manu 1/21; Buhler 1886).

Incidentally 'name' signifies (the physical) identity of an organism; 'actions' specify its working principle and 'condition' reflect on its ecological position, the sum of the adaptation of an organism to climate and other factors.

In *Geetaa*, *Bhagawan* Sri Krishna has explained about the niche with a different approach while explaining the components of *Karma* (action). According to *Saankhya* philosophy five factors are necessary to accomplish all actions (18/13).

- ♦ The following are the factors operating towards the accomplishment of actions, viz. the seat of action (*Adhistaanam*) and the agent (*Kartaa*), the organs of different kinds (*Karanam*), the separate movements of divergent types (*Chestaah*); and destiny (*Daivam*) (18/14).

The physical body of a man (an organism) is the seat or platform on which he works, known as the *Adhithaanam*. Inside the body a personality lives called as the *Kartaa* or *Jivatman*. A body without the *Jivatman* or a *Jivatman* without a defined body can not perform the work. To recognize the body (*Adhithaanam* + *Kartaa*) and the personality in it, a person / organism is named. Thus, in ecological niche name is given prime importance.

The third factor is *Karanam* (the sense organs). This factor is divided into two parts: *Baheekaranam* and *Antahkaranam*. *Baheekaranam* is the physical sense organs (two types: *Jnaanendriyas* and *Karmendriyas*) associated with the *Maanas*, *Buddhi* and *Ahamkaara* discussed earlier. The *Antahkarnam* is otherwise known as *Samskaara*, an abstract principle. The actions and events performed in a person's life time leaves an indelible trace in the subconscious region of his mind which finally gets recorded in the causal body in the form of *Karmic* seeds (Padhy 2006). These seeds are the *Samskaara* (the balanced statement of deeds of past life) carried in the subconscious memory as experience of one's past lives and grows into a character or destiny in the present life. Off course, modern science is yet to pay emphasis on past life. *Samskaara* is the theme of the inner mental environment or the mental impression resulted as the effect of *Karma* transmitted from life to life and forms the bondage of the soul. Thus, *Samskaara* differs from person to person. The *Antahkaranam* plays a vital role alongwith the present experiences of the *Baheekaranam* to perform a work.

The fourth factor is *chestaah* or initiation to perform a work by using the five knowing senses and five working senses. This initiation is to be carried out by the *Kartaa*. So the sense organs without initiation to perform the work and only initiation without the involvement (or existence) of sense organs are meaningless towards the accomplishment of a work. Thus, the *karanam* and *chestaah* together are responsible for the second factor of ecological niche, that is, actions.

The fifth factor is *Daivam*, the most important factor which is understood in different ways. Some consider *Daivam* as destiny (*Bhaagya*), others relate it with God. *Daivam* is an imaginary ecological power that drags man (or any organism) to an environment, where his un-

swerving work gets spoiled or it may so happen, that his unplanned work is completed without any initiation with the help of some unknown power. For example, some elite persons come up significantly with their early life under poverty, misery and struggling, while some foolish and unworthy persons rise to highest posts because of their parental influence, rich heritage and family background. Such coincidence is said to be due to the effects of *Daivam*. From this point of view *Daivam* is the situation or environment, which gives (creates) the ecological address of a person. The effects of *Daivam* may be a life long experience and working area for some one, while it may be a miracle for the other for time being. For example, due to earthquakes when thousands of people die, some one survives while buried under the debris. It is the effect of the *Daivam* or environment that caused their death while the other who survived, may lead a full life term after his rescue. These are the effects of *Daivam* (situation) which presents the environment in a modified form from an unknown direction.

Lord Sri Krishna has said:

- ♦ Whatever action a man performs with his body, speech or mind, whether right or wrong- these (above) five (factors) are its causes (18/15).

SOCIO-ECOLOGICAL PYRAMIDS

Ecological pyramids are the graphic representation of the trophic structure and function at successive trophic levels of an ecosystem, which may be shown in terms of their number, biomass or energy content. The pyramid shows the relationship between the producers, herbivores and carnivores at successive trophic levels. For example, in a grass land, considering the pyramid of numbers, the producers, which are mainly grasses, are always maximum in number. Herbivores the primary consumers like rabbits, mice and insects, etc. are lesser in number than the grasses. The secondary consumers, snakes and lizards, etc. are lesser in number than rabbits and mice. Finally, the top (tertiary) consumers hawks, owls or other birds, are least in number. This forms an upright pyramid.

The above technique of data presentation through graphic representation of pyramids is depicted in *Geetaa*, to project the persons with *Siddhi* in the Human Ecology. *Siddhi* refers to

the devotion and perfection of a man with all divine qualities, are rare indeed.

The *Geetaa* says:

- ♦ “Among thousands of men scarcely one strives for perfection (*Siddhi*), and of those who strive and succeed, scarcely one knows Me in reality (7/3)”.
- ♦ “Four types of virtuous men worship Me, O Arjuna, the afflicted, the seeker after worldly possessions, the seeker of knowledge, and the man of wisdom (7/16)”.
- ♦ Of these (all are noble-7/18) the best is the man of wisdom, ever established in identity with Me and possessed of exclusive devotion. For I am extremely dear to the wise man (who knows Me in reality), and he is extremely dear to Me (7/17).

The theme of the above *Slokas* can be presented with a pyramid graphic model as Figure 1, analysed as follows:

1. Hardly one among thousands of men strives to realize God.
2. Among these striving men, the succeeded rare can be categorized into four groups according to their mode of worship.
3. Of the above four groups, the man of wisdom is the best with exclusive devotion.
4. Some rare one among the above all knows God in the reality.

Human relationship with the environment is as ancient as the evolution of man. May be the science of ecology has developed since a couple of centuries, yet man's endeavour to understand the nature and environment is very well reflected in the religious epics of east and west. The Vedas are at the top among the religious epics throughout the world. The *Geetaa* is presented as the cream of the Vedas as evident from a stanza devoted to concentrate (*Dhyanam*) on *Geetaa*.

All the Upanishads are the cows, the son of the cowherd (Sri Krishna) is the milker, *Partha* (Arjuna) is the calf, men of purified intellect are

the drinkers and the supreme nectar, *Geetaa* is the milk.

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