

Bird as Bio-Indicator which Help to Measure Environmental Health

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Abstract:- This review aims at giving all the information and the key role of birds as bio-indicators of environmental health and help to detect pollution in the environment such as water, air, soil, noise pollution, and heavy metal contamination. Birds are useful to detect forest recovery that properly helps forest management and they have many useful roles to detect global warming and climate change. Some birds help to detect hotspot areas of biodiversity and a recent study even says that birds can tell us about historic events of pollution specifically air pollution. Therefore, many problems according to environmental health and habitat destruction can be measured in a very cost-effective and easy manner with the help of birds as bio-indicators.

Keywords:- Birds, Bio-indicators, Pollutions, Heavy metals, Forest recovery.

I. INTRODUCTION

Scientists have invented various instruments to monitor the health of the environment, and measure the soil quality (Lovett,2012), water quality, pollutants in the air (Dutta,2017), and light and noise pollution (Senzaki et al.,2020). Many forest management uses many complex techniques to measure forest health and productivity, and growth (Dagan & Izhaki,2019) but nature has given us a very beautiful and esthetic tool to measure all those things in a very simple and cost-effective way. We have to observe the birds, their behavior, their migration patterns, etc. Birds can also track past air pollution events around 135 years (1880-2015) (DuBay & Fuldner,2017). That also helps to find whether rules and policies about pollution control and global warming, forest recovery techniques, etc. will work or not (Asefa et al.,2018).

Birds show a paramount role as bio-indicator (Francis, 2017) to solve many environment-related problems in a very simple way. An attempt has been made here to focus on the role of birds as bio-indicator, so, we have to know about bio-indicator first: -

Bio-indicators are those species that are used to determine the environmental health conditions and they can be capable to appraise the environment's integrity using their various biological function. In most cases, physical, chemical, or biological properties that indicate the conditions of un-sampled parameters of the environment, maybe monitored in the absence of all-inclusive data on the entire ecosystem by conservation advocates. This, in turn, stimulates the selection of individual species or groups of species that serve as biological indicators (Francis, 2017). These bio-indicators can measure the condition of an ecosystem such as presence or absence, birth rate and death

rate, the reproductive success of bio-indicators, etc. the bird can tell the quality of ecosystems. Their diversity also indicates the species richness of that ecosystem. Conservation biologists have used bio-indicators for a better understanding of the ecosystem in the simplest method (Asefa et al.,2018).

Bio-indicators are divided into two groups- characteristic ecological bio-indicator and detector ecological bio-indicators.

A. Characteristic ecological bio-indicator:

It is a habitat specialized species that occurs with higher abundance and higher frequency in a particular habitat, but is absent or occurs with lower abundance and frequency in another habitat (McGeoch et al.,2002).

B. Detector ecological bio-indicator:

It is a generalist species occurring in a wider range of habitats having ecological stress. This indicator detects the ecological problems by their frequency and abundance of a particular site of the ecosystem.

These two types of ecological bio-indicators are commonly used for monitoring the state of the ecosystem (McGeoch et al.,2002).

Many other types of indicators are also used to measure the ecological health: -

C. Ecological indicator:

Ecological indicators are to give information about ecosystems and the other impact human activity has on ecosystems to groups such as the private or government policymakers. (Ecological indicator - Wikipedia.org.2021).

D. Biodiversity indicator:

Biodiversity indicators are used to help us to measure the condition of species and ecosystem, like the health of species and unification of the ecosystem, habitat loss or presence of some invasive species, help to protect important biodiversity areas. Indicators help to produce a report about whole diversity to make environmental policies and conservation investments (nature serve.org.2021).

E. Composition indicator:

It is usually the susceptible species such as birds that can estimate the forest composition and detect climate change, global warming, and other environmental stresses (Francis, 2017).

F. Environmental indicator:

This species indicates the environmental stressors in a particular location such as toxic chemicals in soil or pollutants in the environment. Temperature can indicate by

birds as an environmental indicator ([Birds as Environmental Indicators | EnvironmentalScience.org.2021](#)).

Bio-indicators and other types of indicators can be divided according to bioassay:

G. Site-type indicator:

Here, individual species act as a marker for a specific environmental condition. Common Cuckoo can act like this to mark a species richness area or a hotspot of biodiversity ([Morelli et al.,2017](#)).

H. Recovery indicator:

This indicator species helps to measure the recovery rate of the ecosystem or forest. It is done by some local species especially some endemic species such as Himalayan Bulbul in Uttarakhand ([Chowfin and Leslie,2021](#)).

I. Management indicator:

Many bird species help forest management to recover forests and ecosystems([Dagan and Izhaki,2019](#)).

Some other important species which also help to study a particular environment such as dominant species, keystone species, flag species, umbrella species, vulnerable species, and endangered species ([Francis, 2017](#)).

J. Advantages of bird using as bio-indicator:

Birds are excellent bio-indicators. They can indicate environmental stressors very easily as compared to other animals. They help us to understand environmental conditions in a very cost-effective way because they are easily detected by their songs and twitter. Their feather colors and flying behavior are used by ecologists by adopting three different survey methods, which are line transect, quadrat, point count, etc. In ancient Egypt, the arrival of the cuckoo was associated with harvest time was written by Aristophanes, and that indicated a session to change agricultural understanding. Humans also took the knowledge from the bird as indicators([Morelli et al.,2017](#)). The positive benefit of using birds to measure the environment:

These are very easy to detect by knowing their ecology, and behavior anyone can observe those, along with their calls, bright colors, flying habits, etc.; Bird's distribution, migration pattern, abundance, biology, ecology, habitat preferences, life history, etc. are all well-known([Asefa et al.,2018](#)). Birds are top consumers in many ecosystems such as marine ecosystems([Rajpar et al.,2018](#)) thus, contaminations and bio-accumulations are easily measured by them; Lots of birds are considered pollinators and they help disperse seeds of crops and thereby maintain the ecosystem ([Dagan and Izhaki,2019](#)). Only the birds can cover a three-dimensional area of the ecosystem, i.e., they can fly, stay on land and can swim, and even can enter deep water ([Francis, 2017](#)). The birds can cover a broad-spectrum area because they can fly a long distance and the migratory birds can tell us what type of contamination has happened in their route of migration ([Pandian et al.,2020](#)).

Therefore, some researchers also thought that if some birds are declared flag species by the government, the

general people will become aware of their importance and can join in many conservation.

II. DISCUSSION

A. Birds as Indicators of Air pollution:

The birds are very sensitive to air pollution, in the bird population in cities is fast declining([Chowdhury et al.,2014](#)). The sparrow, the pigeon is highly sensitive to air pollution. The sparrow population in India and U.K is reported to decline in many cities. In Andhra Pradesh, their population has dropped by 80%, and in other states like Kerala, Gujarat, and Rajasthan, it has dropped by 20% ([Dandapat and Chakrabarty,2021](#)). It was also reported that in many urban areas where the air pollution level is very high, causing diminishing the population and habitat destruction, over 52% of this has happened in the case of 261 bird species decline since 2000, besides 22%, have declined due to air pollution and many other anthropogenic effects ([Choudhry, 2021](#)). In the early 1900s when air pollution indicator instruments had not been invented then coal miners used canary birds (*Serinus canaria*) to detect the percentage of toxic gas like methane or carbon monoxide in coal mines and whether their levels were too high or not. The Canaries are more sensitive to toxic gases than human beings. If the canary became sick or died, the coal workers knew it was time to exit the coal mine immediately ([Bernal,2019](#)).

Atmospheric black carbon has been avowed as of great concern in public health and the environment for a very long time. It has the property to detect climate change and black carbon derivatives help in global warming. Modern research can examine the black carbon rate in past years and can predict the environmental condition in those years by using birds. The researchers use photometric reflectance data of more than 1300 bird specimen taken from natural history collection and have evidence of the relative ambient concentration of atmospheric black carbon between 1880- and 2015 in the U.S.A([DuBay and Fuldner,2017](#)). That explains how the pollution was growing over the years and after 1960, when many air pollution reduction laws were introduced by Government, the air pollution graph started falling.

In China, the Philippines, India, and United States, many bird lovers' rare pigeons and other birds as those are also good indicators of heavy air pollution. Scientists detected black lungs and enlarged testes in those birds who lived in air polluted areas, especially in Beijing and Manila. However, in less polluted areas the lung and liver contained 3-4 times fewer polycyclic hydrocarbons, which comes from the burning of fossil fuel ([Lovett,2012](#)).

B. Birds as Indicators of Water pollution:

Birds appear as a good indicator of pollution in the terrestrial as well as aquatic ecosystems. Birds such as Kingfisher, Cormorant, Heron, etc. near the river, or pond and usually catch small fishes, insects, insect larvae, etc. from there. If water is polluted very much, then that causes a decrease in the population of that bird because of the water contamination ([Roche et al.,2010](#)). In the marine ecosystem,

sea birds encompass 65 genera, 222 marine and 72 partially marine have been used as good indicators of the marine ecosystem due to cause-effect association with different microclimates and habitats. Here, sea birds are top consumers in the marine food chain and components of the food web. Thus, they can detect any environmental changes and contaminations. Sea bird communities have been used to examine the condition, productiveness, and threats to the marine ecosystem. Monitoring the various aspects of sea bird community parameters provide detailed information on seasonal distribution and migration pattern, foraging ecology, and breeding biology. That, in turn, will help in conservation processes. Sea birds respond more quickly to any environmental changes such as oil spills (In 2002-2003, 60,000-ton oil was spilled near the coast of Portugal and France, and that caused mass mortality of Auks, Common murre, Atlantic puffins, and Razorbills. As many as 20,000 birds died due to this.). Thus, contaminations changed the wetland system and marine ecosystem (Rajpar et al., 2018).

In an aquatic ecosystem, the use of DDT and other chlorinated hydrocarbon pesticides, as per the report of various Pollution Control Boards, the pollution increased in the use of late 1950s. The birds also played an important role as bio-indicators. To reduce that pollution in water the necessary steps were taken. (DDT and bird's eggs, 1970).

Plastic pollution in water is now another big problem in marine and aquatic ecosystems. Many indicator birds such as Fulmars (*Fulmarus sp.*) can indicate the abundance of floating plastic in oceans. Scientists used to collect the dead birds from seabeaches or accidentally killed fulmar by long-line fisheries and examined their stomachs, it was indeed surprising that an average of 12 plastic particles in each fulmar, collected from the comparatively polluted areas, like the coast of California, North-east Atlantic. The birds ingested the plastic particles and died. This problem was more serious in the case of younger birds, because of that after 2000, many countries of Europe as well as the USA reduced the plastic pollution through OS.P.A. R (Oslo/Paris convention for the protection of the marine environment of N.E Atlantic) and M.S.F.D (Marine Strategy Framework Directive) conventions Fulmars were considered as bio-indicators of the marine ecosystem. (Van Franeker and Law, 2015).

C. Birds as Indicators of Soil pollution: -

Many birds collect their food mainly insects, seeds, annelids, etc. from the soil. However, the birds can detect any contamination as their population size will be low in the polluted area. Nowadays in many agricultural fields, birds are used to examine the soil quality. Tree Swallow (*Tachycineta bicolor*), is used in U.S geological survey Board to detect soil pollution such as polychlorinated biphenyls which affect the eggs of swallow and that will give an indication of soil pollutant level. Here, researchers use the swallow because, they are known to move over fairly small distances, rarely more than five hundred meters from their nests. Thus, researchers can attract them to areas of interest by putting out nesting boxes on poles. (Lovett, 2012).

D. Birds as Indicators of Noise pollution: -

Many birds prefer to listening music and some birds, such as Parrots may even dance to mimic their owner. Some birds respond well to music. Many studies prove that birds even have their own choice of music (Rowe, 2019), but birds dislike modern loud electronic music and noise. Anthropogenic noise is increasing faster than the human population. Noise affects the behavior of many animals and humans also. Birds are very sensitive to this noise pollution and that alters their behavior, sensory performance, communication, orientation, foraging, and vigilance behaviors. It also influences egg-laying dates, partial hatching success, clutch hatching, clutch failure, and nest success. Several birds such as Northern Cardinal, Oak titmore, Eastern bluebird, and purple martin in the USA leave cities due to noise pollution (Senzaki et al., 2020).

E. Birds as Indicators of Light pollution: -

Night-lighting is the big reason for light pollution. This is a very crucial stressor for not only birds but also plants, animals, and humans. They all suffer from changing circadian rhythm, mental illness, stress, etc. These types of pollutants mainly affect animal behavior and sometimes their physiology by altering sensory performance (Dutta, 2017). Anthropogenic night-lighting changes activities and interactions mediated by the vision and alter circadian rhythms, which are controlled by photoperiod. This night light shows a negative impact on some bird species such as white-breasted nuthatch, Carolina wren, house sparrow, violet-green swallow, the impact of egg-laying date, clutch size, clutch failure, nest success, partial hatching success, etc. (Senzaki et al., 2020). This causes serious light pollution problems, especially in big cities.

F. Birds as Indicators of Global warming: -

Global warming is the main cause of climate change. Human-induced emission of greenhouse gases, more than 90% is by CO₂, CH₄, CFCs, and resulting in large-scale shifts in weather patterns causing climate change. The temperature is raised on earth at 1°F, which causes many adverse situations such as water level increase in the sea, ice melting in the polar region, desertification and Storm, flood, etc. is more frequent than in past years. It has a great impact on habitat and ecosystem destruction for many species (Climate change - Wikipedia, 2021). Some recent study shows that rising temperature is causing birds to migrate a little earlier in each spring. It finds that the journey to home is shifting forwarding by a little less than 2 days each decade. In the USA hundreds of migrating, species show this pattern. Scientist Kyle Horton of Colorado State University analyzed it by using many high-tech instruments and Artificial Intelligence and from that result, it is clear that tracking global warming changes their migration pattern (Harvey, 2019).

Another study shows that the tracking speed of climate change is not very fast but it is more efficient for tracking global warming than other indicators (Devictor et al., 2008).

G. Birds as Indicators of Heavy metal pollution: -

Heavy metal accumulation is a big problem. The bio-magnification of such chemicals causes a decline in species richness. Its accumulation in the human body also causes health regards. Heavy metal is usually detected by birds through their feathers. As many as 15 species of shorebirds in India had shown the presence of 7 different metals such as Cu, Cr, Co, Zn, Ni, Pb, Hg, etc. on their feathers. The concentration of such metals in their body is – Zn>Ni>Co>Cr>Cu>Pb>Hg. The feathers of shorebirds have a concentration of those metals is increasing at an alarming rate. The researchers conducted research in Tamil Nadu had shown that the concentration of heavy metals in shorebirds is more than in other birds of that area. The shorebirds migrate annually from their breeding in the Indian southern wetlands due to many anthropogenic activities such as fertilizer and pesticide runoffs, industrial effluents near a wetland, the heavy metals get accumulate in the soil. The wildlife and aquatic organisms come under severe threat from this pollution, especially tertiary consumers are affected adversely being the top consumer of the marine ecosystem. Heavy metals could influence physiology, affecting their feeding habits, growth, age, reproductive functions, migration, and distribution. Different shorebirds show indication for different heavy metals such as for Zn, highest in Dunlin, Common Sandpiper, little in Ring Plover, Marsh Sandpiper, Stilt; for Ni, highest in Common in sandpiper; for Pb, Black-wing Stilt, Common redshank, Curlew sandpiper, Lesser, Plover, Eurasian curlew, etc. (Pandiyani et al., 2020).

As an indicator, birds show that heavy metals can't be degraded or metabolized during the self-purification process rather they get accumulated in reservoirs and enter the food web and harm every member of it. Some indicator birds are critically endangered by these pollutants especially Zn and other heavy metals such as the Nicobar pigeon and many Duck species. Scientists also examined that the pollution occurs not only in their breeding grounds but also is found in their migration routes. Heavy metal pollution traces are also found in birds' food particles like an arthropod, mollusks, crustaceans, their larvae, and many annelid species (Dutta, 2017).

H. Birds as Indicators of Hotspot of biodiversity: -

Some recent studies demonstrate that the Cuckoo can predict hotspots of biodiversity in European and Asian countries respectively. Researchers found that in Europe, the Cuckoo is present in the area which is characterized by greater species richness, while it is absent in sites with low species richness. Cuckoo population trends mirror the average population pattern and climate suitability of overall bird communities, Cuckoo is a suitable indicator, even under climate change scenarios. Therefore, the Cuckoo population can help to take conservation and management strategies of the ecosystem. Cuckoo seems to be a great bio-indicator species because common people also track them by their loud vocalization. Scientists need more studies on their behavior (Morelli et al., 2017).

I. Birds as Indicators of Forest recovery: -

Ecological restoration is essential to reverse biodiversity loss, restore ecological processes, and provide ecosystem services in disturbed or degraded lands globally. Birds are considered to be early responders to these habitat restoration impacts due to different life-history strategies and microbial species preferences, thus acting as an indicator taxon for the restoration of ecological complexity during forest restoration (Da Silva and Vicky, 2002; Roels et al., 2019). Birds have been used as biomarkers to capture wildlife responses to recovery progress through natural regeneration efforts, as they are thought to be able to respond rapidly to hazards. recovery efforts. Between 2002 and 2003, Gadoli and Manda Khal forests in Uttarakhand were destroyed by agricultural activities, logging, grazing, industrialization, etc. When scientists noticed a legitimate effort to restore the forest in 2016 and a survey conducted in 2003, they found that many endemic bird species, such as the Himalayan condor, sparrow, yellow-breasted sparrow, scarlet sparrow, gay pheasant, spotted - cockatoo, brown-fronted woodpecker, etc. absent there. In 2003, when deforestation occurred, the census showed 24 bird species, but a recent 2019 census report shows that 4161 new species arrived, they were after reforestation projects. Therefore, this is an increase of approx. 67% of bird species were recorded in 2019 compared to 2003 (Chowfin and Leslie, 2021).

In Israel, the same approach is also taken to ensure forest recovery. Forest management in many countries use the bird as a bio-indicator to understand the biodiversity of that area and measure all ecological attributes. In 1983, 7% of the land of forests in Israel was managed, it was surprising that the study of bird communities in Israeli forests has largely been overlooked that managed forest project was unsuccessful. Then researchers are more focused on bird and environmental relationship for forest management and still, they need more study about it. Some results of their study show that several factors may increase species richness of forest birds and increase forest ecological diversity, those are – plantation size, forest age, plant species richness, successional stage and understory composition, canopy height, trees, climbers, and taller growing shrubs, etc. this support higher density and diversity of bird population and that responsible for good and successful forest management (Dagan and Izhaki, 2019).

III. CONCLUSION

An attempt has been made in this review to summarize all the aspects of birds and their role as an indicator of environmental quality and how we get to benefit from avian indications and alarms. They can measure the environmental health and biodiversity aspects. They can't protect the environment itself but teach us how the factors which make problems for their ecology, diversity, and habitat not only bird's population can indicate many adverse effects on the total food web and the ecosystem due to pollution. They help us to solve much complex ecosystem-related management in a very simple way. Birds sometimes sacrifice

their lives to save us and other organisms. we should encourage many people to be concerned about birds and try to protect their diversity and species richness and that in turn can also protect us from environmental disasters. This aspiration needs more in-depth study to find out how encouraging the bird population, the environmental pollution can be reduced and environmental health can be improved.

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