



ECOLOGICAL DISRUPTION DUE TO NOISE POLLUTION

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Abstract: Nowadays urbanization is one of the reasons for increased air pollution, water pollution, noise pollution and waste generation. In this paper we will focus on noise pollution. Major source of noise pollution is anthropogenic or manmade noise. Noise pollution bad impacts have been observed on humans as well as wildlife. In environment most of animals either anurans or fishes or birds uses sound for communication. The anthropogenic noise pollution is observed to have greater effect on wildlife rather than natural noise. In this review we will be focusing on effect of noise pollution on behavior, foraging behavior, health, reproduction and physiological impacts. Animal shows a variety of responses depending on intensity and propagation of sound.

Keywords: anthropogenic noise, fishes, animals, pollution, behavior

1. **INTRODUCTION:** Sound is a way for communication between animals. When sound become unpleasant or starts causing irritation, it becomes noise. Noise is any unwanted or unpleasant sound that causes damage to health of living being. A given sound at a same time can appear as music to some and noise to others. All this is depends upon frequency, intensity, loudness or duration of sound. Frequency means numbers of vibrations per second of air in which sound is propagating and it is measured in hertz (Hz) (Berg lung et al. 1999).

Animals produce noises that are acoustic signals in response to specific situation. These signals are vocal communication produced from the animal's larynx or sound created by animal's interaction with its environment such as rabbit thumping the ground with its hind foot when it sights danger. Range of sound that animal is capable of detecting depend upon anatomical property of ear of capability of auditory region of brain. Animals use acoustic signal for communication, sexual selection, mother young interaction, interspecies communication.

Sources for noise pollution could vary from natural to anthropogenic source. Natural source may include wind, water, flowing streams, cyclones, avalanches, volcanoes and animals. Anthropogenic sources of noise are often more louder and frequent and more common than natural acoustic stimuli (Patricelli and Bilickley 2006; Popper and Hastings 2009). Noise from airplane, helicopters, road vehicles, train, explosions, metal industries, home appliances, are few examples of anthropogenic noise.

The world health organization 2011 notifies that anthropogenic noise is identified as global pollutant, one of the most harmful forms (Weilgart 2018). Anthropogenic noise is present in both terrestrial and aquatic ecosystem. Anthropogenic noise pollutant is increasing with human population growth and urban development (Slabbekoorn and Ripmeester 2008). Marine life is also mostly affected from anthropogenic noise pollution. The noise from cargo ships, sonar, seismic testing has been continuously increasing from last century.

Animals have a hearing range known as audible range. It depends upon frequency and loudness of sound. Measuring unit for sound is decibel (dB). Different species of animals have different audible range. Animals have

different spectrum for audible sounds with maximum sensitivity at frequency that is inaudible to humans (20 Hz to 20,000 Hz) (Voipio, 1997). For example, rat's peak sensitivity lies between 8 and 50 kHz (Burn, 2008). Lowest frequency of rat has been reported to hear is 0.25 kHz and highest is 80 kHz. Sheep are most sensitive at 7 kHz (Ames and Arehart, 1972).

In oceans, fish use the sound for communication, mating and for avoiding predator. Noise can affect an individual's behaviour, physiology, reproduction, development of marine animals. Kunc et al. (2016) showed that how noise affected the behaviour like parental care, aggressiveness, reproduction, decreased immunity and compromised communication. Anatomical impacts include hearing loss, abnormal development, change in genetic material etc.

Many studies have reported that negative effect of manmade disturbances associated with fossil fuel exploration and exploitation on wildlife. One of the main effects is the habitat loss which is most important impact of anthropogenic disturbances (Barmosky et al. 2011).

The movement against noise pollution is weak in India. Most of people do not consider it as a pollutant and take it as a part of routine life. In India, the Noise Pollution (Regulation and control) Rules, 2000 have been framed under the Environment (Protection) Act, 1986. The ambient levels of noise for different areas have been specified in rules. These are indicated below in given table.

Table 1 : Standards of the noise level.

Areacode	Category of area	Limits in dB	
		Day time	Night time
(A)	Industrial Area	75	70
(B)	Commercial Area	65	55
(C)	Residential Area	55	45
(D)	Silence Zone	50	40

*dB denotes the sound in decibel.

Source: Environment (Protection) Act, 1986 as amended in 2002.

2. Basic Properties of Sound

“Sound travels in form of waves “

Sound is a form of energy which affects our sensation of hearing through the ear. This sensation is produced by longitudinal waves in an elastic medium where vibrations of particles are in the same direction in which wave propagates. When a sound wave passes through air, particles of air vibrate back and forth parallel to direction of sound wave. So when a sound wave travels in horizontal direction, the particles of medium also vibrate back and forth in horizontal direction.

When a sound wave travels through a medium they lose their energy that is why you cannot hear people talking away.

The basic properties of sound are frequency (pitch), amplitude, wavelength, speed and time period of sound wave. Amplitude is the maximum distance travel by wave from its original position. It is the magnitude of compression and rarefaction experienced by medium sound wave is travelling through. Higher the amplitude louder is the sound.

Decibels (dB):

Sound level meter is the device which is used for measuring sound level and it is measured in units called decibels (dB). Decibels are a different type of scale from other scales of measurement. Decibel scale is a logarithmic scale. Decibel is used to quantify sound levels and it's a logarithmic unit indicating the ratio of physical quantity to a reference level. It's a common measure of sound intensity that is the one tenth of bel on logarithmic intensity scale. It is defined as $dB = 10 \log_{10} (P_1/P_2)$, where P_1 and P_2 are relative powers of the sound.

In acoustics, decibel is quantified in relation with a reference which has been set at sound pressure level of 20 micropascals. This reference level is a typical threshold of human hearing perception. The equation used to calculate the sound pressure level or amplitude:

$dB = 20 \log_{10} (s/s_0)$ where s is the observed pressure and s_0 is the reference pressure which is 20 micropascal or 0 dB (measured intensity is equal to reference level).

Sound levels given in dB in water are not same as sound level given in dB in air. Scientist has agreed to use the intensity of sound wave with a pressure of 1 micropascal as reference intensity for underwater sound. Underwater dB is abbreviated as dB re 1 micropascal.

3. How does acoustic communication get affected?

Acoustic signals reduce in amplitude, frequency and temporal structure as they travel through a medium. The distance above which an acoustic signal is efficient depends upon power output of source, barrier during propagation and ability of receiver to extract information from the signal that is transmitted. The level of signal propagating between two points depends upon the relationship between spatial arrangement of the source and receiver, wavelength of sound and flow resistivity of ground.

Change in amplitude: When sound travels through a medium, there is a change in amplitude of sound due to spherical spreading. When sound propagates away from the source it transfers an amount of energy into medium and that energy is spread over a large surface area and that will lead to spherical loss. Spherical spreading leads to decrease the pressure and intensity by 6dB for each doubling of distance from the source (point source). For example when distance is increase by factor of 4, then we have to decrease the intensity by 12dB.

Attenuation: It can be a reason for change in amplitude of signal in environment. Attenuation caused by atmospheric absorption, reflection, scattering and boundary conditions. Insects often communicate near ground and have large effect on signal attenuation. Signal attenuation is more near the porous surface than the non-porous surface like water. A soft (porous) surface for high frequency sound behaves softer as compared to low frequency sounds and that's why attenuation will be greater for high frequency sound. This is one of the many reasons why communication between animals on soft ground is greatly reduced.

However, hard surfaces like water act as good sound reflector. Communication over water can increase the amplitude of signal by 6dB. Paul and Walker (1979) showed that male short tailed crickets have 14 times great broadcast area at elevated branches than on males communicating on ground.

Absorption: Atmospheric absorption is one of the reasons for loss in frequency of signal. Communication in water is less affected by absorption because atmospheric is 100 times greater than in water at same frequency (Michelsen, 1978).

Vegetation, water passing, rustling of leaves and twigs can also affect sound across a wide frequency range (Slabbekoorn, 2004). Vegetation cause reverberation of sound that result in sound degradation. Effect of vegetation on sound varies with season like in summer effect on signal will increase as density of vegetation increases (Perla and Slobodchikoff, 2002).

4. **SOURCES OF NOISE POLLUTION:** Studies have showed that majority of organisms whether its birds or fish or any other animal, all are affected by anthropogenic sources of pollution.

Industrialization- Progress in technology has resulted in creating noise pollution. Textile mills, printing presses, engineering establishments, and metal works etc. contribute heavily towards noise pollution. In industrial cities like Kolkata, Ludhiana, Kanpur etc. the industrial zones are not separated from the residential zones of the city which cause annoyance and discomfort. Different commercial activities include transportation of goods from one place to other using trucks also create noise in respective areas. Commercial aircraft are also contributes

in commercial and industrial noise. Ocean noise level is also increasing due to growth in global trading activities. If this activity continued to grow, ambient ocean noise level will be increasing intensely.

Traffic Vehicles- Noise pollution from traffic vehicles is major source of anthropogenic noise pollution in today's life. It is one of the fastest growing environment pollution. Traffic noise is originated from traffic vehicles especially old vehicles with no maintenance. Heavy traffic vehicles due to their heavy engine and load also contributed in noise generation. Traffic noise reduced foraging efficiency in most bats.

Rail Traffic- Railway traffic generates sound mainly due to vibrations induced by small roughness on wheel and rail surfaces. Noise from train includes: 1) diesel exhaust 2) engine and air intake 3) cooling fans 4) electric generator and electric traction motor. The rapid transit trains (like metros) are short, therefore their noise duration time is less as compared to lengthy trains. Although train horn is important for alerting the people that train is about to pass but it will also increase the heart rate of animals. When train pass through the forests, it can interrupt communication between the animals residing nearby railways track.

Air craft noise- Noise from planes flying over residential area impairs people's ability to work learn in school and sleep. Army, Navy and commercial aircraft are noise sources. A lot of noise pollution is added to atmosphere by launching o rockets, explosives and shooting practices.

Some of the other sources are social events, construction activities, household chores, fireworks, agricultural machines and some defense equipment. Construction activities like construction of dam, bridges, buildings, flyovers have to be continued to meet the demand of increasing population also creates noise pollution. Firework is a common thing during festivals and cultural ceremonies. Apart from air pollution, the intensity of their sound create noise pollution

Aquatic sources-The aquatic environment consist of both biotic and abiotic sounds that are essential for survival and reproduction of marine organisms. Marine organisms can produce biotic sound in many ways. Source for biotic sound are fish, invertebrates, marine mammals and other organisms. It is essential for them to communicate, mating and prey detection. Organisms like *Melanogrammus aeglefinus* can produce the sound by vibrating their swim bladder. Abiotic sound sources provide information about surrounding environment. It can be divided into two categories- natural background sound and anthropogenic sound.

Natural phenomenons that contribute to aquatic sound include wind, waves, currents and turbulence, earthquakes. Marine animals like *Cetaceans* produce sound which is used for communication, navigation and foraging. Human activity in marine environment is most unavoidable component of oceans noise. It can be impulsive (explosions, air guns, pile driving) and non-impulsive(drilling, shipping).

Explosions- Explosives used for construction, removal of unwanted structure. These are one of the strongest anthropogenic sounds in marine environment. Sound from explosives propagate equally in all directions and can be detected over large distances.

Industrial activities and construction whether in ocean or along shoreline can contribute to underwater noise? Some of the examples are coastal power plants, pile driving, dredging, tunnelboring. The noise level from drilling are typically lower than those seismic surveying. Additionalnoise is generated during oil production activity.

Production activities can generate source level as high as 135dB re 1micropa at 1km from source (Greene and Moore 1995)

Sonar- Active sonar emits high intensity acoustic energy and receives scattered energy. Sonarsystem can be categorized as low frequency (<1000), mid frequency (1-20 kHz), high frequency (>20 kHz). Military sonar is used target detection and localization. These are operated during both training and combat operations.

Table given below is showing sources of anthropogenic noise in the sea with various frequenciesand intensity levels (instead of dB , dB referenced to 1 micro Pascal is used because sound intensity given in dB in water is not same as given in dB in air)

Table 2 : Anthropogenic noise sources and their respective frequency and intensity level.

Types of anthropogenic sound	Frequency	Intensity level
Bottom founded oil drilling and mining	4-38 Hz	119-127 dB re 1 micropascal
Pile driving	30-40 Hz	131-135 dB re 1 micro Pa
Drillship	20-1000 Hz	174-185 dB re 1 micro Pa
Seismic airguns	100-250 Hz	240-250 dB re 1 micro Pa
Navy sonar	100-500 Hz	~215 dB re 1micro Pa
High frequency marine mammal monitoring sonar	~3000 Hz	~220 dB re 1 micro Pa
Medium size ship (ferries)	~50 Hz	150-170 dB re1 micro Pa
Boats(<30m in length)	<300 Hz	~175 dB re 1 micro Pa
Small ship	20-1000 Hz	170-180 dB re1 micro Pa

Sources- Richardson et al.,1995 , Conservation and development problem solving team, 2000.

5.Effects of Noise on Human Health

Long term exposure to noise is a major health risk. Several scientific studies have shown that noise exposure can result in hearing disability, heart disease, annoyance, disturbance of sleep anddecrease in performance of students and employees. Loud noises at school make it challenging for children to concentrate and may affect the teacher student communication also. This may affect child's performance and their confidence. Below I have discussed some of risk related to noise exposure.

Hearing Impairment: It is the decrease in ability of person to hear sound around him. Hearing loss may be temporary or permanent. Damage from the noise depends upon loudness of sound and duration of exposure to that sound. Loud noise can damage membrane of cochlea and may lead to permanent hearing loss. You might have noticed when you leave for concert you don't hear as well as before but hearing returns within few hours. This is because of damaging hair cells and they will take some time to recover. It has been found that sound less than 70dB does not cause the hearing damage irrespective of duration of exposure. The eventual result of hearing loss is depression , job opportunities and loneliness.

Sleep Disturbance: When a person sleep disrupts, it will also affects person mood it performances and its health also. Good sleep is necessary for individual health to function properly. Except this sudden noise during sleep causes to increase in blood pressure, heart rate and increase pulse amplitude also.

Cardiovascular Disturbances: Noise can affect both endocrine and autonomic nervous system that can affect cardiovascular system. This effect will come with long term exposure to noise level above 65dB or with acute exposure to 85 dB or above this level. This may activates the hormonal response that will lead to temporary increase in blood pressure and heart rate.

Individual *mental health* is equally important as much physical health. Noise pollution could be one of the reasons for bad health. It may be the reason for anxiety, disturbance, stress, nausea, headache, change in mood, aggressive behaviour.

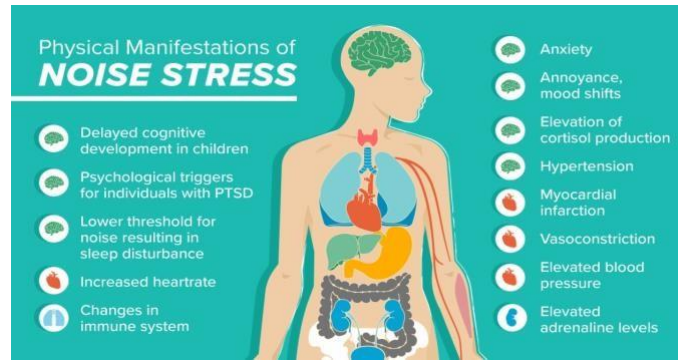


Figure 1: Image depicting health effects of noise pollution

A survey has been done by Narendra Singh and S.C. Davar (2004) on effect of noise on different age groups. They choose Delhi for conducting this survey. The data was collected with help of questionnaire and the analysis of data has been carried out in percentage. Results showed that the effect was not same on all of the age groups. After observing the table it has been concluded that there is increase effect on hearing and deafness in people of age above 60. However, disturbed sleep and more aggressive has been observed in people of age group 40-60. Beside this young people face more interference with communication because of noise. Table given below is showing the effect of noise on different age groups in percentage.

Table 3 : Effect of noise on different age groups

	Effect of noise (in %)		Age Groups			Total
	0-20	20-40	40-60	Above 60		
Interference with communication	97	96	95	83	94	
Effect on hearing	68	57	79	92	71	
Cause annoyance	73	78	81	75	77	
Result in deafness	26	31	35	54	35	
Disturb sleep	68	94	95	92	88	

6. Effect of Noise on Animals

Effect of noise on animals varies due to different hearing ability. Different animal species vary their response to specific noise. Their reaction depends on duration of noise exposure, intensity of sound, physical condition of animal and also on physical environment of animals. Comparison between different species has shown the variability in tolerance to noise level. General response of animal to stress includes activation of neural and endocrine system, increase in blood pressure, available glucose and blood level of cortisol has also been observed. Due to high intense noise, effect on prey predator relationship has also been seen. Some animal's starts migrate from place of high intensity sound. Let's discuss the changes or response of animals to anthropogenic noise.

6.1 Behavioural Response: It has been studied that noise has impact on behaviour and coordination. Animals in particular area appear to respond to sudden noise by freezing, moving away from sound, startle responses. Instead of repetitive noise, the unpredictable or sudden noise causes more effective or stressful condition. In a study (by Castelhana- Carlos and Baumans, 2009), animals were reported to be more active during morning than in afternoon because of general increase in noise level by that time of day. Exposure of laboratory animals to hidden noise leads to abnormal behaviour and impaired learning. It has been reported by Jhonson, 2006 that

Guinea pigs will jump when exposed to sudden loud noise (140-143dB). Sudden sounds are more surprising than the regular ones (Burn,2008). Sound from low altitude aircraft approx. 112dB at milking parlour could result in adverse behaviour such as kicking and stomping (Morgon and Tromborg, 2007).

Behavioural responses were also observed in marine animals. A experiment has been conducted in Alaskan Beaufort Sea to observe the behavioural response of Bowhead whale (*Balaena mysticetus*) to active geophysical vessel. Four different part of experiment was conducted in different parts of sea on interval of few days. Earlier studies (Franker et al., 1982 , Reeves et al., 1983, Richardson et al., 1984) have assumed that geophysical vessel should be approximately 10km closed to observe the behavioural response to airgun blast. The result of experiments showed that whales respond to blasts at range of less than 10 km and strongest responses were observed within 5 km of sound source. Behaviour change in form of huddling in western Beaufort and change in surface behaviour in western Polaris were observed when sound of airgun reached to intensity of 142dB and 157dB at distance of 3.5 km and 8.2 km respectively. Partial avoidance to vessel by whale were observed in western Beaufort and western Polaris at distance of 3.5 and 7.6km while total avoidance for all experiment occur at range of 1.3 to 7.3 km with sound intensity 152 to 165dB. Travelling and feeding behaviour of whales were influenced by approaching seismic vessel. However, whale responds differently to different sound and different intensity. It has been noticed effect of sound disappear within one hour after the disturbances.

Some behavioural studies have shown that (*Trichechus sp.*) Manatees (also known as sea cow) are able to recognize the boats coming towards them. They change their depth, diving behaviour, swimming speed and orientation (Nowacek S.M et al., 2004, Miksis Olds et al., 2007 , Ryeyk et al., 2018). These reactions were more noticeable when vessels travel at speed and in close proximity to animal (Nowacek et al., 2004).

Table 4 : Negative effects of anthropogenic noise on animals

Species (Marine animals)	Type of anthropogenic noise	Effect
P.auratus	Seismic air-gun shooting	Induce frighten response (Fewtrell & McCauley,2012)
C.pallasii	Boating and shipping noise	Induce avoidance response (Schwarz & Greer.1984)
C.clypeatus	Boating and shipping noise	Decrease in defence capability (Chan et al.,2010)
M.densirostris	Mid frequency sonar	Disrupts foraging (Tyack et al.,2011)
E.australis	Vessel noise	Modifies calling behaviour (Parks et al.,2007)
Species (Terrestrial animals)	Type of anthropogenic noise	Effect
Goat	Jet noise (Sugawara et al.,1979)	Reduced milk yield
Dairy cow	Tractor engine sound(97dB) (Boucek et al.,1983)	Increase glucose concentration & leukocyte count in the blood
House mouse	Aircraft(120dB) (Chesser et al.,1975)	Increase adrenal weights
Domestic dog	Sudden loud noise (Stephens 1980)	Increase in plasma corticosteroid concentration
Rhesus monkey	General noise(85dB) (Peterson et al.,1981)	Increase blood pressure
Guinea pigs	General noise(128dB SPL) (Beagley 1965)	Hearing loss

6.2 Anti-Predation Behaviour: Predation is a biological interaction where an organism (predator) kills and eats the other organisms (prey). This predator prey relationship occurs naturally in environment and it is a positive, negative relationship where predator is benefitted and prey is harmed. But by the time the evolution take place and prey organisms develop anti predation behaviour. It has been studied that noise pollution is affected animals anti predation behaviour. For studying the same an experiment was conducted to observe how anti-predator behaviour of European seabass (*Dicentrarchus labrax*) got affected because of anthropogenic noise (I. Spiga, N. Aldred, Gary S. Caldwell, 2017). In this experiment 54 fishes we observed in a water tank under different sound sources and with 30 minute acclimation duration.

Anti-predator response of fish exposed to drilling and piling noise was compared to ambient noise conditions. When predator was introduced under ambient noise condition, fish significantly reduced swimming velocity and became unmovable in response to predator. While the fish which is subjected to piling noise show increase attacking behaviour when challenged and the fish which is exposed to drilling noise spent most of the time in safe zone.

It has been observed that fish subjected to noise did not show stillness which is an indication of change in anti-predator behaviour. After approx. half an hour of stimulation, fish start recovering its swimming activity and also show increase in distance travel showing recovering activity. But at same time some variables did not return back to normal measurement which was measured before predator appearance. This shows the alertness of fish to predation (Millot et al., 2009). Fish subjected to drilling and piling noise has higher level of vigilance in comparison with fish in ambient noise conditions. Some short term and long term effects has also been observed. Fishes exposed to drilling noise show short term effects like spending more time in safer zone and increase in turning rate. On other side, fish exposed to piling noise show long lasting effect like turning in a minute after the predator appear and show high behavioural responses than the ambient ones. This anti-predator behaviour has also been observed in sympatric fishes: Stickleback and minnows. They observed that first one respond more quickly to predator during additional noise recording playing while later shows no difference in their response. Stress response has been noticed during increased noise level resulting in alertness and vigilance. (Wright A J, Bateson M et al., 2007) (Charmandari E, Tsigos C, Chrousos G, 2005).

6.3 Foraging or Acquisition of Food: Most of the animals have to search for their food to complete their energetic needs. Previous studies have shown a lot of competition in between animals of whether same species or different species for food. Even if we exclude the competition for time, there are several other factors which affect the foraging activity of animals. One of the major factors is anthropogenic noise. Boats, ships, sonar, small vessels, they are considered as major source of noise for underwater animals and affect most of animals activity. A shore crab activity was observed in an experiment in response to anthropogenic noise. When a shore crab came out of the shelter for food, then its response was observed for food capturing or eating activity with low frequency of playback noise of boats and sonar. However, playback noise recording cannot be compared with natural boat noise. But still some reactions were observed like fear of predation or losing of food item. It has been observed that there is high competition in decapods crustaceans for food acquisition.

Damsel fish was also observed for foraging patterns in Mediterranean Sea. It's a representative zooplanktivorous key species in Mediterranean Sea. For observing the Damsel fish, an approach by Ellison et al., was used to notice how playback noises affect feeding behaviour of damselfish. Also interference in feeding activity was observed when a fish was forced to move from its area. Noise with high intensity may be responsible for its decreased time for food searching. Eurasian perch when exposed to noise disturbances, negative effect was observed on feeding behaviour (less feeding attempt compared to control ones).

A species of gleaning bat (large mouse eared bat *Myotis myotis*) was observed in respect of traffic noise. This specie uses prey generated sound instead of echolocation for identification and spotting of prey. Food acquisition is avoided by these bats when they exposed to traffic noise playback (Schaubetal, 2008; Siemens and Schaub 2011). It can be concluded that anthropogenic noise is a reason for decreased foraging efficiency.

6.4 Communication Interference and effect on hearing: In our daily life most of us have experienced the communication interference because of some other sound or noise which is louder than ours. When a sound is having some frequency get affected by other sound having higher frequency, then low frequency sound get masked over by higher frequency and this overlapping of sound is known as masking effect. Masking effect will occur only when receiver is not able to detect the signal in loud background noise. Efficiency of masking depends on frequency of noise and signal. If frequency of noise is similar or higher to signal then only masking will be efficient. This masking effect has been studied in animals also but it has been noticed that all species does not show similar reactions to anthropogenic noise.

For example, *Rana taiphensis* (Sun and Narins 2005), they can change their reaction to noise because of plastic calling behaviour and could decrease the effect of masking. While on other side European tree frog (*Hyla arborea*) (Lengagne 2008), cannot change their call structure to tackle with noisy environment. Anurans were reported to show their reproduction dependent on sound and if masking effect occurs it will inhibit communication between them. This will show a significant effect on mating success. However, they can reduce the masking effect by adjusting the timing or frequency of their call. Some of male frogs (*Boana bischoffi*), when exposed to noise, show the change in their original position and start moving away from source but keep calling. Aggressive calling was also observed in between of periods. In a study (Dooling and Leek, 2018), it has been shown that human hearing is better than hearing of birds for same level of noise. In a noisy environment sound of bird singing is barely audible to humans. So, it will be approx. negligible to birds present at same location as of humans.

Except communication interference, exposure of high intensity noise for longer duration could be a reason for permanent hearing loss which may affect the communication too. Permanent loss occurs because of the damage to inner ear structure which cannot be repaired. If hearing ability of person is recovered within few days or week, it is referred as temporary hearing loss. This is noticeable only if there is some interference with routine activities. Hearing loss is measured as threshold shift in dB (decibel). Positive threshold shifts indicate the hearing loss. Physiological damage to ear of marine mammals because of exposure to air-gun or some other high intensity equipment is also of same importance as others.

A study by (Enger, 1981; Hastings et al., 1996) showed that exposure of high intensity sound (over 182dB re 1 micro Pa) for longer duration may be reason for damaged sensory hair cells in ear of fishes. Hearing threshold of Juvenile wild caught and aquaculture snapper was studied and it was observed that they had their bandwidth of hearing sensitivity ranging from 100 to 2000Hz. Auditory threshold for wild caught snapper ranged from 101dB re 1 micro Pa to at least 145dB re 1 micro Pa and for aquaculture snapper, it was from 111dB re 1 micro Pa to 145dB re 1 micro Pa. Both of these observed to have decreasing hearing ability with increase in frequency. Moreover, the hair cells of ear were not recovered even after 58 days exposure to air-gun.

Auditory threshold was observed in two otophysan species *C.auratus* and *P.pietus* to white noise at 158dB re 1 micro Pa for 12 and 24 hour significantly. Both of this species in their sensitive hearing range shows effect to noise exposure. Andre et al., 2011 examine the four cephalopod species after exposure to experimental noise emanating device and observed the damages to hearing sensory epithelia.

6.7 Changes in population distribution and catch rates: Whenever an aquatic animal is found in different location, for example, inshore species found offshore, termed as mass stranding (more than one animal located together). An example of change in population distribution due to anthropogenic noise is mass stranding of Cuvier's beaked whales (*Ziphius cavirostris*) and giant squid (*A.dux*) (Guerra et al., 2011; Frantzis, 1998). In the northwestern Gulf of Mexico, Kemp's ridley sea turtles and bottlenose dolphins' mass stranding's was observed because of the explosives which are used to remove oil platforms in offshore.

Decline in population of killer whales (O.orca) was observed in the largest marine park Broughton Archipelago after exposure to high amplitude acoustic harassment devices (Morton, 2002). Emigration was observed in *P.phocoena* and *T.truncatus* due to pile driving noise (165- 185 underwater dB). Except for straight migration noise exposure can also lead to vertical distribution of population. Wind farm noise was observed to affect the

vertical distribution of *P.phocoena* (Carstensen et al., 2006). However species like *P.microps*, *M.scorpius*, *P.minutus* show no effect on community structure because of wind farm noise (Wilhelmsson et al., 2006).

Catch rate reduction of fishes is also an effect of anthropogenic noise which may be a reason for economic loss (Skalski et al., 1992). *S.goodie*, *G.morhua*, *S.chlorostictus* was observed to show decline in catch rate because of exposure to seismic air gun shooting (Lokkerborg et al., 1993; Engas et al., 1996). However, *P.cygnus* show no effect on catch rate on exposure to seismic air- gun shooting (Parry and Gason, 2006).

6.8 Other health impacts: Just like noise affects the human health negatively in same way it affects the health of wildlife animals whether its birds, anurans, fishes, mollusks. Besides behaviour alterations, masking, foraging, threshold shift, noise is also responsible for physiological responses of animals. Generally the physiological stress response is induced due to noise in marine organisms. Reduced immunity, abnormal metabolism, nervous activity, reduced performance, effect on reproduction are all because of high intensity or short intensity for longer duration noise exposure.

Exposure from seismic water gun (197-225dB re 1 micro pa) in white whales was observed to found increase level of the epinephrine, norepinephrine and dopamine (Romano et al., 2004). In same way high level of aldosterone was detected in bottlenose dolphins after subjected to seismicair-gun noise (213-226 dB re 1 micro pa) (Romano et al., 2004). Elevation in cortisol levels was observed in several species, like goldfish (*Carassius auratus*) (Smith et al. 2004), seahorses (*Hippocampus erectus*) (Anderson et al. 2011).

C.maenas was found to show high consumption of oxygen when subjected to a playback of ship noise indicating great stress and high rate of metabolism (Wale et al., 2013). Reduction in food intake and growth rate was also noticed in fishes disturbed by noise (Lagardere, 1982; Anderson et al.,2011). Decline in immunity and increase in heart rate due to noise exposure was detected inwhite whales (*D.leucas*) (Lyamin et al., 2011). Marine animals use sound for their mating process or for identifying or communicate with their male partner but it can have harmful impacts too if intensity of noise is very high. Chronic stress could also be a reason for decline in reproduction for years (Boonstra et al. 1998). Stress can lead to low mating chances and may have some effects during parental care periods.

In an experiment response of spiny chromis was observed in both ambient noise and motor noiseplayback near the nest. As a result decreased in interaction with offspring and increase in predation risk was observed for motorboat playback noise as compared to ambient noise (Nedelec et al. 2017). Ruffoli et al. 2006, observed decline of plasma testosterone level in male mice when subjected to 100 dB white noise for 6 h/day. This kind of hormonal deficiency can be problematic for mate behaviours and reproduction success (Van Duyse et al. 2003). An alterationin population sex ratio was also observed by Sobrian et al. 1997. However different species respond differently to noise exposure depending of intensity of sound.

7. **Noise pollution mitigation:** To protect the human health and animals, it's necessary to mitigate the unwanted noise. World health organization has announced the noise pollution as underestimated threat. It has been seen that urbanization and population are continuously growing for years and with same sources for noise pollution are increasing. There has been no sign of slowing down of noise pollution. If we want to protect our wildlife we have to be more aware about this and need to find strategies for mitigating or managing noise pollution so that it has no bad impact of humans as well as animals.

Some management principles were supported by the United Nations Agenda 21 (UNCED 1992) and Environment and Health (London Charter 1999). This includes- A) precautions should be taken to protect public health. Noise level should be decreased to lowest achievable level in every situation.

-B) all expense in association with monitoring and management of noise pollution should be paidby polluter.

-C) whenever possible one should prevent noise pollution.

There are a diversification of methodologies for mitigating roadway noise including: use of noisehurdle, putting limits on vehicle speeds, limiting number of vehicles, using a good tire design or by setting standards and guideline for noise level limits for main noise sources. Setting up limits: Limits for vehicles on noise emission has been set by many countries(Sandberg 1995). The maximum permissible limits for noise level in Europe are 69dBA for motor vehicles, 77dBA for cars, and 84dBA for trucks. Besides this a different low noise trucks has been introduced in Europe (Lang 1995). Speed limits and type of surface also matters for noise level. In addition ban on heavy vehicles during night may further reduced noise emission. Setting rules for stopping the unnecessarily honking of cars.

Managing noise from railways: Major source for noise from railway is its engine and sound from rail-wheel contact. It can be reduced by keeping the good maintenance of train and its engine. Replacing the steel wheels with rubber wheels could also reduce the noise.

Construction of wall to absorb noise: This barrier wall made up of absorptive materials so that it can mitigate the sound effects. It doesn't completely block all the noise but it can reduce the noise level by 5 to 10 decibels. The wall decreases the noise either by absorbing it, reflecting it or forcing it to take longer pathway. Tough surfaces like concrete are consider as good reflector.

Plants as a sound absorber: Absorption of sound by plant depends upon leaf area density and also on soil characteristics. It has been observed that absorption coefficient of high density clayis found to be low. Soil with high permeability and low density is expected to show high value of acoustic absorption. The presences of plant on this type of soil have a significant effect on absorption coefficient (Kirill V.H, 2013). Evergreen shrubs can be used as noise blocker. Broadleaf evergreen are more effective than the narrower one. Plants like hollies and junipers can be used for excellent noise reduction.

Some other ways which can be used are: use of absorbents in noisy machineries, proper lubrication and better maintenance, creating limits for noise level and strict rules to follow the limits.

Underwater anthropogenic activities are also creating noise pollution which is observed to be threat for marine animals. Noise pollution disturb their activities, alter behaviour of animals and also changes in their feeding activities are also observed. Mitigation measures for shipping activities were given by IMO, 2014. For mitigation the design of ship was taken into consideration like hull should be designed so that wake field is as homogenous as possible and hull and propeller design should be adapted to each other. Other operational and maintenance consideration for noise reduction are clean the propeller to reduce the surface roughness and cavitation. Maintain the smooth hull surface and reduce the speed of ship. Speed reduction can be effective measure to mitigate noise from shipping (Weilgart, 2007 ; Merchant et al., 2012).

Methods for mitigating pile driving noise are use of bubble curtains, isolation casings, dewatered cofferdams and hydro sound dampers. In bubble curtains, freely rising bubbles injected by perforated pipes encircles the pipe (Caltrans, 2009 ; Carlson and Wieland , 2007; Lee et al., 2011). Measures to reduce the noise from seismic surveys are use of deterrent devices, restrict the usage of airguns during the line change, restrict the seismic surveys at night, determine its

range to the animal and restrict the air-gun when sighting an animal. Low frequency acoustic sources can also be used.

Mitigation measures for naval sonar were given by Dolman et al., 2009. The identified mitigation methods were avoidance of sensitive areas and avoid surveys during sensitive time periods. Same measures were taken for mitigating the multi-beam echo sounders. Active acoustic monitoring can be used to mitigate single loud sounds. Acoustic monitoring can be used as an alarming source.\

8. **Conclusion:** The motive of this review is to compile and compare the data from the previous studies on noise exposure. Majority of literature showed alterations in behaviour and feeding activity of animals. Both marine and terrestrial animals act differently to different noise intensity. Some of animals show adaptation also after exposing for longer duration. The effect of same noise intensity is found to be specie specific due to differences among species. Besides observing the animal response to noise exposure, the sound intensity, difference between the source and animal and the propagation loss and ambient sound measurement is also equally important. Without knowing the activities of animal in ambient environment we cannot compare changes that occur in activities of animal during the noise exposure. Signal masking was also observed in animals. Nowadays, birds count is so less that one can rarely see a bird in urban areas and this is all because of continuously increasing noise pollution from roadside traffic and construction sites. So, from the above review we can conclude that each and every species has its own ways to respond to noise pollution. We have to consider noise pollution as a great threat to our wildlife and find ways to mitigate pollution so that it has minimum or no effect on animals.

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