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What Does "Noise Pollution" Mean?

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Abstract

Noise features different characteristics that make it different from every other "classic" pollutant. Noise is invisible; it does not smell; it disappears when the source is turned off and leaves no traces in the environment. In addition, when people perceive something wrong about their hearing capacity, it is often long time after the beginning of noise exposure. This fact contributes to strengthening the misconception that noise is not harmful to human health or, at least, efforts and funds aim preferably at controling and decreasing the emission of other pollutants. Adding to this, most people tend to consider that noise is the price to pay for accessing to the amenities of the Technological Era and it is indivisible and inevitably linked to them. Last but not least, noise pollution could adversely affect ecosystems and ecological services. Then, how is it possible to convince the decision makers that noise pollution is one of the major current environmental problems? The aim of this paper is to discuss step by step the applicability of noise of a "pollution" definition, as a way to ease the understanding that lowering environmental noise levels should be prioritized: because it will lead to a healthier and better society.

Keywords

Noise Pollution; Effects of Noise; Noise Exposure

1. Introduction

Several definitions of "pollution" may be found. Lilia Albert definition has been chosen to guide this discussion:

"*Pollution refers to the presence or introduction of substances, organisms or forms of energy to substrates or media they do not belong to or exceeding their typical quantities, for enough time and under conditions that allow interfering with health and comfort of people, damaging natural resources or altering the ecological balance of an area.*" [1].

Applying this statement to noise is an interesting challenge.

According to Anderson [2], pollutants shall be classified as "stock pollutants", "fund pollutants" and "flow

pollutants". *Stock pollutants* are the so-called "cumulative pollutants". As these cannot be processed by the environment, these are accumulated. *Fund pollutants* are those that the environment can partially process; the environment has some absorptive capacity for these. *Flow pollutants* are short-lived: "(these) *can be initially damaging, but are dissipated into environmental sinks with relative ease. Examples include light, noise, and heat pollution, biodegradable litter and smog*" [2]. In the last group, noise and heat are at a particular disadvantage because they cannot be seen: when photographs of a discotheque or a pneumatic hammer are shown, usually the viewer does not imagine how the scene sounds by watching the picture.

2. Acoustic Energy

Regarding the three categories proposed by Albert [1], noise should be classified within "forms of energy". Both the emission of acoustic energy and its presence in the environment may be considered pollution.

Acoustic energy is related to the vibration of the source and the particles of the medium where the sound wave propagates. It is the sum of the kinetic and potential energy related to the acoustic wave.

Sound can be produced by sources of very low acoustic power; *i.e*. a deafening claxon that sounds 3 m away from your ear with a sound pressure level of about 100 dB has a sound power of about 90 mW. If this claxon sounds during 2 seconds, you will receive an amount of acoustic energy of 0.18 J, that is not enough to raise 2 cm a mass of 1 only kg.

To this is added that the emission of acoustic energy gets cheaper and cheaper every day.

3. Where Do Sound Waves Propagate?

The acoustic waves need a material medium to propagate. So, from a wide point of view, air, soil and waterways could be potentially affected by an excess of acoustic energy. Sound waves are a kind of acoustic waves that are able to generate hearing sensation in humans.

It is generally accepted that the audible field of humans is a zone inscribed into ranges from 20 Hz to 20.000 Hz and 20×10^{-6} Pa to 200 Pa. In spite of this, in 2003 Leventhall [3] demonstrated that human ear should be sensitive to much lower frequencies for very loud intensities. Based on Leventhall's studies, Sejer Pedersen [4] delved on the connection between infrasound perception and annoyance.

Sound can be emitted by acoustic waves propagating in a solid medium. This is explicitly taken into account e.g. in the Room Criteria curves (RC) for rating acoustic comfort.

Propagation in waterways is a very important issue as well. The development of bioacoustics since 1970 to our days has enlightened a lot of topics and there is a wide research field to delve [5] [6].

However, when focusing on people as the major receivers, air should be intended as the main medium of propagation of noise. Therefore noise is said to be an atmospheric pollutant or, more accurately, a physic atmospheric pollutant.

4. How Much Noise Is Too Much Noise?

According to Albert's statement [1], then the focus should be on assessing if the "typical quantities" of acoustic energy in one point of the atmosphere are exceeded or not. This question has not an obvious answer; also, "typical quantities" should be stated in advance. Perhaps the main issue should not be focused exceeding or not the *typical quantities* of acoustic energy occurring in one particular place, but assessing if those are *reasonable quantities* for prevent or minimize adverse effects.

The expression "reasonable quantities" lacks precision at all because there is not a unique answer: some local concerns should be considered to assess "how much noise is too much noise", and not only on standards and legal frame: characteristics of the receivers have an important role on their response to noise [7] [8]. Age, gender, ethnics, health and nutrition status, music preferences, education level, among other labels, have incidence on sensitiveness to noise.

Even if there are some quantitative features of sound that are directly related with annoyance and then with the perception of it as "noise", the physical properties are not enough to explain when and why a *sound* turns to *noise*. Some complex components are to be considered.

In last decades several researches have been carried out in different countries with the aim of better understanding the relationship between sound and annoyance. The main results converge to state that *the concept of*

noise is a social construction which involves a negative social value on certain sounds, so that even music can be socially considered as noise [8]-[10].

Environmental sound pressure levels can affect the social behavior of people. The ability to withstand noise is said to be inversely linked to aggression, as stated Vázquez Estivill [11]: "*People who are exposed to high noise levels are more aggressive and less tolerant*". Also, helplessness increases as environmental noise levels do [10] [12].

It is well-known that Schopenhauer had a critical point of view about the linkage between noise and socio-cultural levels. He referred to noisy societies in a very hard way, *i.e*. as follows: "*It is not fortuity that less developed countries and regions are also the noisiest ones*" or "*Intelligence is a human faculty inversely proportional to the ability to withstand noise.*" [10] [13].

Lizana [14] states that noise is a cultural issue, so that policies and guidelines could influence on public actions in this regard, particularly through the importance that society assign to each of four basic principles: the principle of caution, "the polluter pays", the precautionary principle, and continuous evaluation.

5. How Much Lasts "Enough Time"?

5.1. Dose

It is stated that a pollutant agent should be present *for enough time and under conditions that allow interfering with health and comfort of people* (...) [1]. This connects to one of the main concepts in toxicology: the *dose*. Indeed, toxicology has been developing as a discipline since S.XV; its birth is attributed to Paracelsus, who stated: "*dosis sola facit venenum*", *i.e*. all substances are potentially harmful, depending on how much of it reaches and acts on the receiver [1].

In most of cases, especially when referring to toxic substances, dose is usually expressed as the product of the concentration of the agent by the exposure time. The way that the dose to produce certain effect could be achieved is not unique. This leads to classify the type of exposure in terms of its duration: an *acute* exposure refers to a short-term episode while it is said *chronic* when it occurs over a long time, although concentrations are low [1].

Toxic effects refer to biological changes in an organism as a result of exposure to a chemical agent; these could differ because of exposure patterns, route of entry and other facts. They could be immediate or delayed, reversible or irreversible, lethal or not. Some sub lethal effects involve anatomical or functional damage, physiological imbalances, increased sensitivity to other harmful agents and behavioral changes [1].

5.2. Dose of Noise

The concept of "*dose of noise*" is usually applied to assess occupational exposure to noise and it is expressed as a percentage. It refers to the ratio between the amount of acoustic energy that reaches a unit area in a certain time, related to the acoustic energy that could reach the same area when the sound pressure level is the admitted sound pressure level for occupational noise exposure and the time is the legal duration of the working day. Thus, a 100% Dose is the maximum acoustic energy that a worker may receive during a working day. Any exceedance on exposure should be reported as overdose, *i.e*. a dose of noise greater than 100% [15].

5.3. Widening the Concept of Dose

The aim of the concept of "*dose of noise*" is to assess noise exposure based on the acoustic energy that reaches one receiver in a given period of time. It should not be seen as related to "passive" situations where the receiver *is reached* by the noise, but also to those situations where the receiver *chooses* being at a noisy place or producing high levels of noise.

Regardless of *occupational exposure*, noise exposure could be classified as "environmental" or "social". When the exposure to high levels of noise is not chosen, it is said to be an *environmental exposure*. It refers to a non-wanted exposure related to sounds/noises that reach the place where the receiver is, e.g. traffic noise, music from stores, or neighborhood noises, and which the receiver is not able to reject. If he/she should stay in that place, this exposure will be non-evitable.

On the other hand, *social exposure* is chosen by the receiver. It involves voluntary attendance to noisy places as well as the "consumption" (in a wide sense) of high levels of sound, e.g. the use of personal music devices at

high volume, the listening to loud music, the practice of sports like shooting, as well as other noisy activities [13].

Environmental sources of noise in urban areas have been fairly the same since at least the second half of 20th Century. Beristáin describes them in Mexico City in two papers published twelve years apart and it is interesting to notice that main sources remain the same: road traffic and transportation, industrial and commercial places, formal and informal peddlers, public and private civil works, leisure places (discotheques, rock concerts, public and private meetings and parties, local village fairs, domestic household and neighborhood noise [16] [17].

Noise sources in our society can be classified in the same way that sources of other pollutants [1], into one of four groups according to the underlying causes of their existence:

- Productive activities, not only industries but also agriculture, cattle, mining and power generation.
- Non-productive activities, among which traffic is the major source and one of the most worrying ones all over the world. In 2011, the Regional Office for Europe of the WHO released a key inform about the effects of traffic noise that states [18]:

"(...) *at least one million healthy life years are lost every year from traffic related noise in the western part of Europe. Sleep disturbance and annoyance, mostly related to road traffic noise, comprise the main burden of environmental noise*".

The detail of such amount of years is also striking [18]: "61,000 *years for ischemic heart disease*, 45,000 *years for cognitive impairment of children*, 903,000 *years for sleep disturbance*, 22,000 *years for tinnitus and* 587,000 *years for annoyance in the European Union Member States and other western European countries*."

The Report concludes: "*Sleep disturbance and annoyance, mostly related to road traffic noise, comprise the main burden of environmental noise.*"

- Social processes, as population growth, migration, unplanned growth of cities, development of new housing and industrial devices. Land use planning and zoning are the most ancient measures to manage noise troubles. About 600 B.C., in the regulations of Sibaris city, Calabria, stated that no one could have cocks at home, and the "hammer workers" had to live outside of the city. Perhaps this is one of the oldest provisions that explicitly determine land use to noise pollution [13].

Since the enactment of Directive 2002/49/EC of the European Parliament and of the Council of the European Union [19], every country in the Union must carry out strategic noise maps for all its cities with 250,000 inhabitants or more, communicate their findings to the Council of the European Union, put in practice concrete actions to improve environmental acoustic quality, and review and renew strategic maps into a given period. Ten years later, although there are still difficulties with its implementation and in the harmonization of methodologies, the usefulness of the strategic noise maps is not questioned [20] [21]. Moreover, there are several national and provincial regulations requiring strategic noise maps in cities with less than 10% of the threshold number stated by the EU Directive [22]. As stated by Bañuelos [21]: "*A strategic noise map, the action plan and the subsequent management are opportunities to solve noise problems*." He also said: "*the high initial cost for the Administration to build a strategic noise map is not on the map itself, but on the corrective measures that must be implemented because of him*."

- Cultural patterns, as "use and throw", which leads to the increase of productive and non-productive noise-related sources.

The increase of noisy habits and the early "initiation to noise" [23] should be mentioned, since there are several physiological responses that strongly relate noise, aggression and addiction [23] [24].

One of nowadays greatest challenges involves social and cultural features: the management of the noise produced by leisure activities in the night at the so called "pink zones", the zones of the cities where nightlife is concentrated.

While historically the main challenge was to oblige all leisure places to have a proper acoustic isolation to avoid generating high sound levels in neighbors houses, other conflicts and problems have emerged some years ago. There are two major issues: the accumulation of people outside the nightlife clubs, and the parked or circulating vehicles with powerful audio equipments turned on. In public areas as streets, squares or parks, responsibilities are often not clearly assigned within the different Administration agencies. In some countries the Police should only take actions in case of a public safety issue.

Then, to avoid exercising violence on the rights of people who are noisily enjoying, violence on the rights of neighbors to rest and sleep is exercised [13] [24].

6. Interferences with People's Health and Comfort

Noise can produce many deleterious effects. The occurrence or not of them depends on several facts, as the type of exposure and the target organ.

6.1. Hearing Impairment

Effects on hearing faculties are known long ago and have been deeply studied. The first reference about a causal relationship between exposure to noise and hearing impairment dates back from the early S. XVII. About the "quarter of the coppersmiths" in Venice, Ramazzini wrote [25]: "*…at Venice, these workers are all congregated in one quarter and are engaged all day in hammering copper to make it ductile so that with it they may manufacture vessels of various kinds. From this quarter there rises such a terrible din that only these workers have shops and homes there*; *all others flee from that highly disagreeable locality*. (...) *the ears are injured by that perpetual din, and in fact the whole head, inevitably, so that workers of this class become hard of hearing and, if they grow old at this work, completely deaf. For that incessant noise beating on the eardrum makes it lose its natural tonus*; *the air within the ear reverberates against its sides, and this weakens and impairs all the apparatus of hearing. In fact the same thing happens to them as to those who dwell near the Nile in Egypt, for they are all deaf from the excessive uproar of the falling water*".

The major effects of noise exposure on hearing are three [24]: acoustic trauma (an immediate and permanent effect due to an acute exposure); temporary shift of hearing threshold level (an immediate effect after an acute exposure that could be reverted by hearing rest); permanent shift of hearing threshold level (a differed and permanent effect caused by chronic exposure). Both the shift of hearing threshold level-and also tinnitus, if are to occur-may appear as reversible effects, but they also could evolve to permanent damages.

6.2. Extra-Auditory Effects

Noise exposure could also produce many extra-auditory effects, as respiratory disease (asthma, bronchitis), cardiovascular disease, hormonal responses (stress hormones), weakening of the immune system, sleep disturbance, psychiatric diseases, depression, aggression, annoyance, cognitive impairment, interference with verbal communication, frustration, social isolation, helplessness... [24]

The Final Report of an analysis on the health effects of noise exposure based on the WHO Large Analysis and Review of European housing and health Status (LARES) [26] confirms the evidence of significantly relation between noise exposure and some negative effects on health.

Currently, annoyance is considered as one of the main effects of noise exposure. WHO LARES states [26]: "*A central effect of noise is annoyance. Annoyance is defined as a feeling of discomfort which is related to adverse influencing of an individual or a group by any substances or circumstances. Annoyance express itself e.g. by malaise, fear, threat, trouble, uncertainty restricted liberty experience, excitability or defenselessness. With chronically strong annoyance a causal chain may exist between the three steps health—annoyance—disease*."

Another key-result is that "*noise has to be classified as an independent risk factor for the respiratory system.*"

WHO LARES has confirmed that people who suffer strong annoyance or severe sleep disturbance caused by noise, have increased risk of acquiring many diseases. According to the Final Report [26], the major effects on *people strongly annoyed by noise* have been: "*significantly elevated relative risks in the cardiovascular system, the respiratory system, and the musculoskeletal system as well as by depression in adults*; *stroke in elderly people*; *and on the respiratory system in children*."

The major effects on *people with severe sleep disturbances by noise* have been: "*significantly elevated relative risks in the cardiovascular system, the respiratory system, and the musculoskeletal system as well as with depression exist with noise induced sleep disturbances. Many of these diseases increase with age and therefore in children only appear rarely*."

In the case of *children*: "*significantly elevated relative risks in the respiratory system as well as in migraines* (*self reported*)".

The Report states that further research on nightly environmental noise exposure and neighborhood noise is needed: "*The results point out that it is necessary to improve the sound insulation in residential buildings*".

6.3. Annoyance

Annoyance is not only related to direct interference at the moment, but also to many other elements, sometimes

not so obvious e.g. to be affected, disturbed or attacked by anything that oneself cannot control. The expected responses include moods such as irritability, anger, anxiety, nervousness, eagerness, among others. People who do not react in these ways usually do so through other moods, often described as restlessness, disquietude, depression or helplessness, as well as discomfort, distrust, frustration or wear and tear [10].

Although the adaptability of people is larger than imaginable, tolerance to high sound pressure levels without feeling discomfort should not be interpreted as current or future absence of noise-related adverse health effects. Recently, the research results of Lam *et al.* [7] have enlightened a warning about the occurrence of adverse effects on human health in spite of the absence of annoyance, reinforcing the concept that noise and annoyance are cultural constructions.

Based on its lack of specificity and its high prevalence, annoyance is often considered as a symptom of intolerance and unsociability. This idea is reinforced by some legal systems in which the "*sufferer of noise*" (as Miyara said) shall demonstrate he/she is being harmed by the noise source he/she has complained about, instead of forcing the legal responsible of the source to prove that no damage has been caused to him/her [24].

As noise threats people's comfort and welfare, it is one of the major causes of neighborhood bothers and troubles. Complaints and delations can easily begin, and when a legal noise-related conflict is installed, it is often difficult to solve. Until the sufferer achieves his/her complaint to be considered by the Authority, the noise source is not forced to change or interrupt its operation. Just the opposite, the claimer will not only continue to suffer from unwanted exposure to noise and to absence of rest, but he/she also must bear the costs necessary to configure the required proofs, accept the presence of strangers (inspectors, technicians, even the responsible of the noise source) in the privacy of his/her home during rest hours whenever a measurement, a run-test of sources or something else is required. All this without mentioning that must accept epithets such as grumbler, grouty, fadish, intolerant, asocial, mad, crazy, loony, goofy, just to mention some of the kindest ones [10] [24].

6.4. Noise Suffering, Aggression, Depression, Migraines

The direct linkage between noise suffering, depression, migraines and aggression are based on the biochemical processes related to hormones and neurotransmitters. When exposed to high sound pressure levels, increased release of adrenaline and noradrenaline occurs in direct relation to the sound pressure level [27]. Cortisol release is augmented too [23]. These hormones are associated with depression and aggression.

The injection of adrenaline caused by the exposure to high noise levels stimulates SNS, producing an increase in cardiac and respiratory rhythms, pupillary dilation, piloerection, and produces an emotional state that has been described as "nonspecific" or "euphoria", but not "anger" [27]. On the other hand, cortisol regulates the speed of glucose consumption by the cells, raising its concentration in blood.

This effect should oppose aggressive reactions, since aggression is related to low levels of blood glucose. Alcohol has the same hypoglycemic effect; the relationship between alcohol and aggression is well established and the possibilities of noise to catalyze a process toward alcoholism are real: the addiction to noise can be a passport to other addictions, starting with social drugs [23].

Increased availability of norepinephrine in the brain could generate impulsive and/or aggressive responses. Ramírez states: "*Since noradrenergic system participates in fight and flight, it is easy to understand how increasing the function may predispose a person toward impulsive aggression*" [27]. The *fight and flight* (or *fight or flight*) or *stress response* refers to the non-conscious responses of the nervous and endocrine systems to prepare the body for action, when a danger or a threat is detected.

Many antidepressant drugs usually act on the production or reuptake of norepinephrine or of serotonin [28]. Often, these may be combined for the treatment of depression.

Serotonin, one of the most studied neurotransmitters, is closely associated with multiple behaviors, such as depressive and aggressive. Too much serotonin causes relax and sedation, while its deficit is associated with depression, anxiety, eating disorders, feelings of pain, aggressive behavior. On substances that act on serotonin reuptake, Ramirez states [27]: "*The drugs that increase serotonergic activity reduce impulsivity and reinforce tolerance to a standby state*; *on the contrary, that produce a decrease serotonergic increase the frequency and intensity of aggressive and risky reactions*". Thus, interferences between neurotransmission and neuroregulation could cause behavioral disorders as well.

Aggression in humans is a complex response to different causes among which are genetic but also cultural and environmental factors. Unlike other animals, humans may control and even disable many aggressive re-

sponses. According to neo-association trends promoted by Berkowitz [29], while frustration causes a willingness to manifest aggressive acts, also the whole baggage of learnt behaviors, reactions and acquired habits are present. These "aggressive warning" might define the outcome: the materialization of aggression or the inhibition of it, depending on the previously learnt responses to this kind of stimulus: tolerance or violence.

The alteration in serotonin release is considered as a possible cause of migraines [30]. In fact, some antidepressant drugs, especially those that act selectively on serotonin reuptake, are effective to treat migraines [28].

Ashina [31] has demonstrated that depression is associated with an increased risk of progression to chronic migraine among patients with episodic migraine. The risk of transformation to chronic migraine also increased with the severity of depression. Patients with moderate, moderately severe, or severe depression had significantly higher rates of transition than patients with mild or no depression [31].

More than 75% of people who suffers from migraine present low tolerance to high noise levels [30]. Also, a relationship between noise sensitivity and depression is expected.

Stanfeld found a significant association between depression and high sensitivity to noise but for some reason he did not rely on his finding. He suggested that the sensitivity to noise could be exposing negative affectivity but could also be an indicator of vulnerability to a wide range of stressors. Some years later, the WHO LARES results have finally confirmed that sensitivity to noise and depression are significantly related.

7. What about Alteration to Ecosystems?

Most animals use acoustic signals to orientate, hunt, defend themselves and communicate [6]. One of the best known counterexamples is to tortoises, for which the ear is an almost nonexistent sense: they hardly perceive vibrations caused by the movement of large animals close to them.

Most species have some degree of susceptibility and response to acoustic stimulation and often suffer adverse consequences to environmental noise. Some birds are sensitive to high noise levels, at least during the breeding season. The distances at which effects have been verified vary from a few meters to 3 km. Songbirds are particularly sensitive to noise [32]. Other species can adapt to intense levels of continuous noise, as in the case of urban birds [33].

Each species has its own emission and hearing abilities according to its natural ambience in order to success on feeding, reproducing and defending itself and its breedings. It has also a natural response and adaptive potential to environmental changes. These are uncertain until they have been studied. For example, in their research on nestlings of white-crowned sparrow (*Zonotrichia leucophrys nuttalli*) exposed to traffic noise, Crino *et al.* [33] found just the opposite results they expected at the beginning of their research. They remark that research addressing noise impacts on adult birds has found wide variation among species in the response to noise, some of which increase abundance in noisy areas and others a decreasing one.

The major interest on acquiring a better comprehension of them should be preventing long-term alterations due to anthropogenic forcings [34].

The main adverse effects of noise on animals are presented below.

7.1. Hearing Impairment

Hearing loss reduces the ability of orientation and defense because of augmented difficulties for properly detecting, discriminating and localizing of signals [5]. Altered behavior and increased stress could be related or 2nd order effects.

In 2010 Barber, Crooks and Fristrup [35] proposed some new concepts to assess on noise impact on wild life. Among these concepts, they defined the "*effective listening area*" as "*the zone in which animals can communicate with each other or listen to other animals* (*calls or movements*)". This concept is useful to systematize many research results, and easies specialists other than Biologist to interact in interdisciplinary teams.

Animals are especially focused on listening to sounds at the edges of audibility, especially weak flapping or traces of predators or prey, so even a small increase in the background noise could prevent capturing the sounds that need to be heard [5]. The researchers showed that a 3 dB increase in environmental noise, which could be considered negligible in many cases, can reduce by 30% the effective listening area of some animals. If increasing of background noise level is 10 dB, the effective listening area is reduced by 90% [35].

In 1993, Krause introduced the concept of "*aural niche*" [36]. According to him, each species has an "aural niche" related to its own voice, *i.e.*, with the frequencies, intensities, timbre and duration of the sounds it emits.

The whole vocalizations of creatures that inhabit in a given zone define a unique "*vocal fingerprint*". He states that this "acoustic fingerprint" or "sound fingerprint" could be used as an indicator of the biological integrity of the area [36].

For those animals with a developed attention sense, the increase of background noise represents a distracting factor which could define the difference between death and survival [37].

7.2. Interference in Communication

Several investigations of the direct and indirect effect of noise on various species of amphibians show the importance of environmental sound for their survival [32]. When there are communication disturbs and/or misunderstandings during the breeding season, the risk of reproductive failure may increase.

Frogs use their song to recognize individuals of the same species, warning about the presence of predators or defending their area and resources; the female even selects her mate by his croak, which allows her to infer the male's physical condition, if it is a big one and other attributes [38]. Any obstacle in the communication of frogs alters their behavior and can restrict their conservation. Environmental noise disturbances adversely affect the frogs, by avoiding them to detect predators in time or interfering with their communication. Some frog species try to adapt the characteristics of their song to the acoustic environment in which they live. They try to sing louder because of increased environmental noise levels e.g. near roads. However, many times not only the loudness of the song is increased: the animals also sing higher, that is, in higher acoustic frequencies. This is the case of *Ranitomeya bombetes* [38]: attempting to communicate despite the anthropogenic noise during the breeding season, this species may lose the ability to reproduce with individuals from locations with lower levels of background noise: its singing would not be recognized even by a close possible couple as it is in a higher pitch.

7.3. Learning the Song

Human actions tend to increase the loss of habitats, for example by promoting sensitive species to leave from their original places. Some of them success but others fail to survive in zones with a different sound fingerprint [36]. If environmental sound levels generate adverse conditions of audibility, these animals should increase their efforts to achieve their singing to be heard, especially during breeding season. If an individual fails to learn certain repertoires of song after reaching breeding sites, its communication skills and thus its reproductive success might diminish.

According to Nemeth [39], birds exhibit the Lombard effect, as mammals do. It is a common phenomenon in humans' communication: the louder the background noise is, the louder the person speaks.

Depending on their vocal plasticity and their size, birds would sing not only louder but at higher frequencies. However, it is not possible to predict behaviors without a solid basis with focus in real data: "*In laboratory experiments, budgerigars* (*Melopsittacus undulatus*) *and elegant crested tinamous* (*Eudromia elegans*) *increased both the amplitude and frequency of their calls when background noise levels increased, but whether this occurs in the field is unknown. By contrast, the begging calls of juvenile tree swallows* (*Tachycineta bicolour*) *were both louder and higher when experimentally exposed to noise in the field, but in the laboratory under similar conditions only call amplitude increased*".

7.4. Stress

Creatures under stress have lower resistance to the action of other stressors. Tolerance limits to stressors could be also reduced during procreation season and for neonate and aged individuals.

In the case of noise, it could affect community dynamics in a complex way [34]. Indeed, there are still more questions than answers to understand this complexity.

Facing a danger, the main response is releasing stress hormones. Noise may affect social animal dynamics and increase their perception of threat. For prey species, noise may also increase stress levels by masking the sounds of approaching predators and increasing the perception of risk from predation. It may also cause stress due to short-term disruptions in behavior, such as startling or frightening animals away from food or other resources. Further, if individuals associate a particular type of noise, such as road noise, with a danger, such as vehicular traffic, this may provoke a stress response. In most cases the cost of chronic adrenal activation in response to noise pollution is unlikely to be outweighed by the benefits, and thus the net result may be adverse

[40].

Francis states that it is also possible that acoustic interference with significant information, as localizing preys and predators or communicating with breeding, could lead to high stress levels [34].

7.5. Annoyance

When background noise increases, it could result in reducing activity areas, habitat loss or displacement, making individuals lose interest in certain sites that have arrived to be considered adverse.

Noise-related displacements of animals could have indirect effects on plants, by disrupting the behavior of animals that have a key role in pollination and seed dispersal [34]. A research carried out in 2011 - 2012 by the National Evolutionary Synthesis Center NESCent, North Carolina (USA) found that some animals increase their activity in noisy environments while others avoid noisy places. *Archilochus alexandri*, a hummingbird species, visited five times more flowers in noisy places than in quieter areas, suggesting that some plants exposed to elevated noise levels may have greater reproductive output relative to individuals in quiet areas.

Francis [34] studied the presence and abundance of *Pinus Edulis* seeds and two species that exerted the greatest influence on seed-removal rates: the western scrub jay (*Aphelocoma californica*) and the *Peromyscus* mice. *Aphelocoma californica* should avoid noisy areas because noise can mask their vocal communication. On the other hand, noisy areas are interesting for *A. alexandri* and *Peromyscus* mice. This probably reflects indirect responses to noise: noisy areas may represent refuge from predators and key competitors that typically avoid noisy areas, including jays. *A. alexandri* may preferentially settle in noisy areas because of lower nest predation pressure from *A. californica*. Similarly, *Peromyscus* mice populations may increase in noisy areas not only because of reduced competition with *A. californica* and other jays for feeding, but also in response to reduced predation by nocturnal acoustic predators that may avoid noise, such as owls.

One scrub jay may cache up to 6000 *P. edulis* seeds in locations favourable for germination during a single autumn. Many seeds are relocated and consumed, but many others go unrecovered and germinate. *Peromyscus* mice might function as conditional disperser under some circumstances, but their primary role is as seed predators: they consume a large proportion (about 40%) of the seeds they find and typically cache many encountered seeds that are not immediately consumed; these reserves are often recovered and eaten (greater than 80%) along with seeds cached by other individuals or species. An increase in the mouse population will result in lower seed germination. Reduced *P. edulis* seedling recruitment in noisy areas may eventually generate a decrease of the number of these trees, but this will be noticed some decades later. According to Francis [41]:

"*This means you can reduce the number of trees in noisier areas, but this could have gone unnoticed for many years because the pinions grow very slowly. And if there are fewer pine habitat will be favorable to the hundreds of species that depend on these trees to survive. Seed removal, seed predation and seedling recruitment data should be noise-conditioned so they have the potential to indirectly affect woodland structure*."

8. Conclusions

There is no doubt about considering noise as a pollutant.

Regarding its features, it should be classified as a physical atmospheric pollutant.

Noise could cause many of the adverse effects of pollution: it can damage human health and comfort, as well as negatively affect ecosystems and ecological services.

Based on the definition of "Health", the WHO has demonstrated that environmental noise should be considered a major public health aggressor; more than this, it has showed that a serious and generalized public health problem related to noise is already installed.

Some of the main problems of nowadays society should be related and possibly increased by the omnipresent high levels of noise: stress, aggression, depression, addictions, decrease of intellectual capacities, severe sleep disturbances, by others.

Noise could have deleterious effects on ecosystems and ecological services; some significative effects might be detected many years later and perhaps it would be too late.

The soundscape should be intended as an identity feature, social construction that could and should be improved.

Reverting the present trends is a great challenge indeed! Why pursuing this path is a must? Because lowering environmental noise levels will lead to a better and supportive society.

There are no instantaneous solutions, but a long way to go.

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