Small Computer-Based System for the Analysis of Respiration Response to Atmosphere Pollution

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ABSTRACT:

An on-line LINC-8 computer system has been used to study the effects of atmospheric ammonia pollution on the respiratory system of New Zealand White rabbits and Holstein calves utilizing autocovariance and Fourier analysis procedure. Power spectral density and autocovariance profile plots revealed that increased respiration amplitude and decreased respiration frequency resulted in both species from exposure to ammonia levels between 50 and 100 parts per million.

KEY WORDS AND PHRASES: Small computer application, respiratory system response, atmospheric pollution study, frequency response analysis, correlation analysis
CR CATEGORIES: 3.12, 3.80

Respiratory rate of man and animals has long been used as one of the indicators of physiologic status. However, the respiratory rate determination typically has been based upon very limited numbers of intermittant observations, thus obscuring changes in any underlying respiratory patterns.

The periodic nature of respiration invites Fourier analysis although the mass of data has represented a truly formidable problem prior to the advent of digital and hybrid analog-digital computers. These coupled with FM type magnetic tape recorders, have made it possible to do a variety of either on-line or off-line analyses.

Goodman, et al (1964, 1966) examined the oscillatory nature of respiration in resting man using FFT computer routines and various trend removal procedures to determine period lengths of "cycles" in ventilation parameters. Their studies indicated that at least six "almost periodic" superimposed oscillations were involved. Band rejection digital filtering has been used (Womack,1971) to eliminate respiratory arrhythmias from heart rate records and also to aid in estimating respiratory wave forms from heart rate information. Mayan and Merilan (1972) report an approximate one-third reduction in respiratory rate but no significant effect on observed "period length" in variations in depth of respiration with rabbits exposed to 50 or 100 ppm NH_3. Attinger, et al (1966) have pointed out the need for extreme care in coupling transducers to biological system and for dynamic calibrations prior to experimental runs if on-line digital analysis is to be successful.

Initial work on the study reported here involved power spectral density and autocorrelations of one hour segments of tape recorded respiratory rate data using SEL-840 and IBM 360-50 computers. Subsequently the data analysis evolved into essentially real time procedures with alternate processing pathways as shown in Figure 1. The PAR 100 correlation computer (hybrid analog-digital device) involved a time constant of 20 seconds whereas analysis on the various small (4K) computers (LINC 8, PDP 8-L and PDP 8-E) have been restricted to specific time segments of respiration data.

Figure 2 illustrates the type of data from the animals while typical individual plots of power spectral density and autocorrelation analyses by a small digital computer are shown in Figures 3, 4, and 5 for a rabbit exposed only to control air conditions. Figures 6 and 7 show sequential autocorrelogram plots for a rabbit under control air conditions, then exposed to atmospheres containing 50 ppm, 100 ppm, and finally 150 ppm anhydrous ammonia. Exposure to the 150 ppm NH_3 atmosphere was terminated when electrocardiograms indicated severe stress. Figure 8 shows the 3 hour post exposure period for this animal with a return to pre-exposure respiratory rate and apparent cyclic variations in "depth" of respiration as the respiratory control mechanisms strive to regain the essentially steady state observed during pre-exposure conditions.

In our experience, the "contour" plot has proved extremely helpful in visualization of changes occurring during

relatively long periods of time while the individual PSD and ACF plots have provided more detailed information for short time segments.

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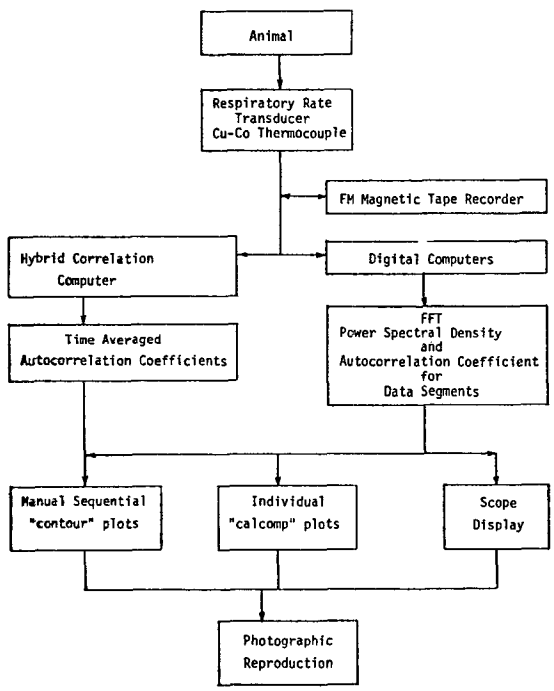

Figure 1. Schematic Representation of Small Computer Based System for the Analysis of Respiration Response

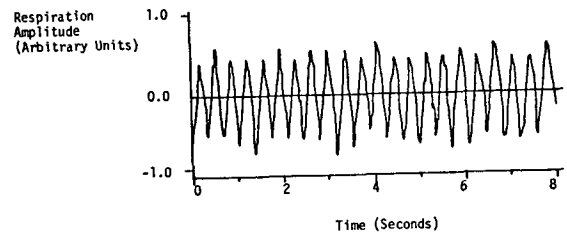

Figure 2. Typical Respiration Data

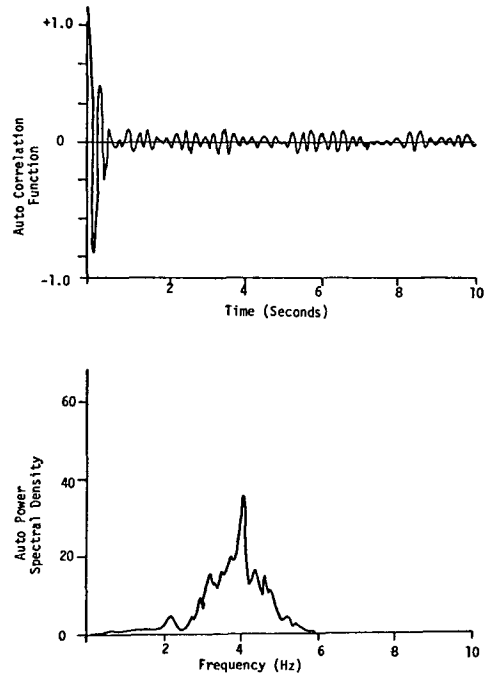

Figure 3. ACF and PSD of Initial Rabbit Respiration Rate Under Control Air Conditions

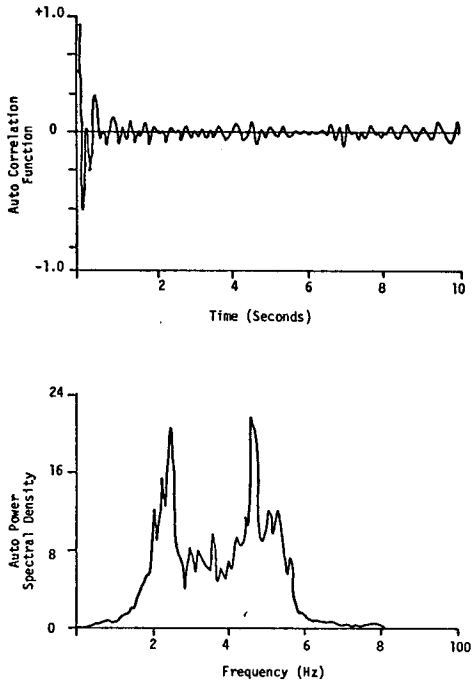

Figure 4. ACF and PSD of Rabbit Respiration Rate after 5 Minutes Under Control Air Conditions

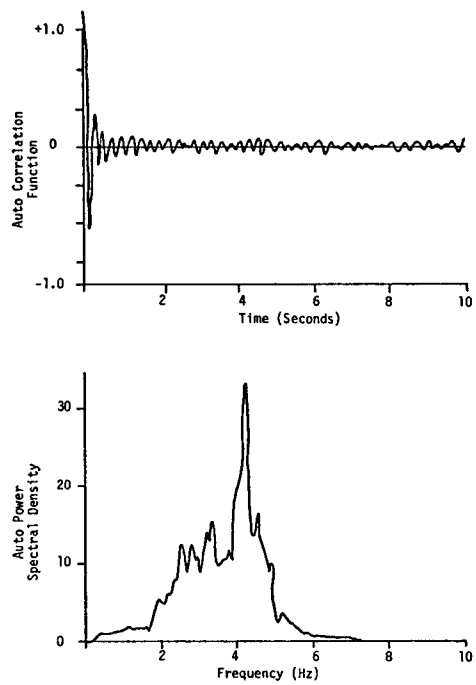

Figure 5. ACF and PSD of Rabbit Respiration Rate After 10 Minutes Under Control Air Conditions

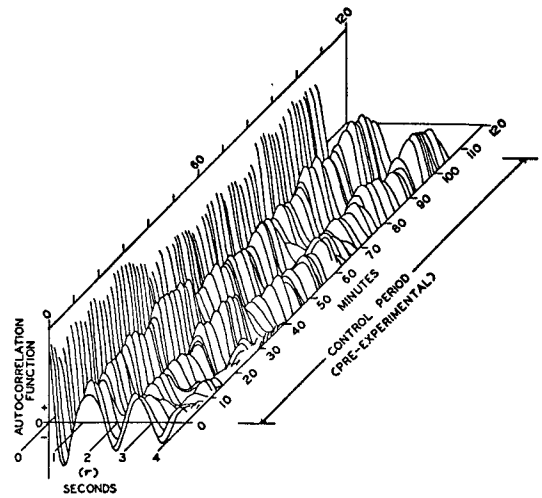

Figure 6. Sequential ACF of Rabbit Respiration Under Control Conditions

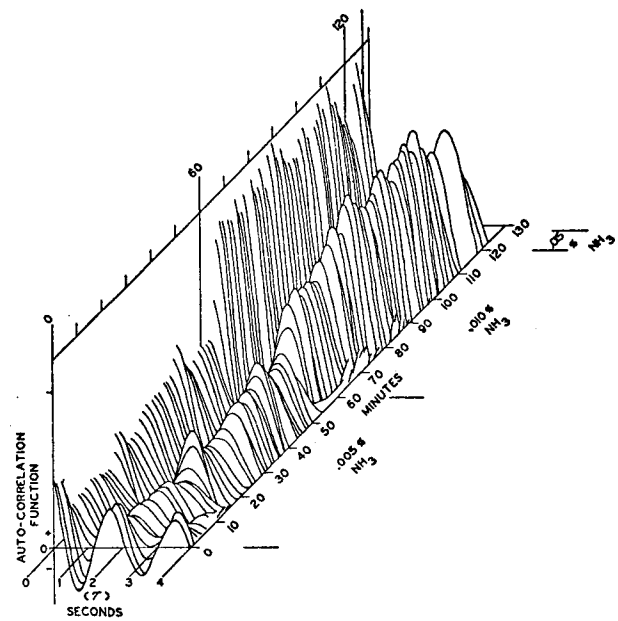

Figure 7. Sequential ACF of Rabbit Respiration During Exposure to 50, 100, and 150 ppm NH_3 in Air

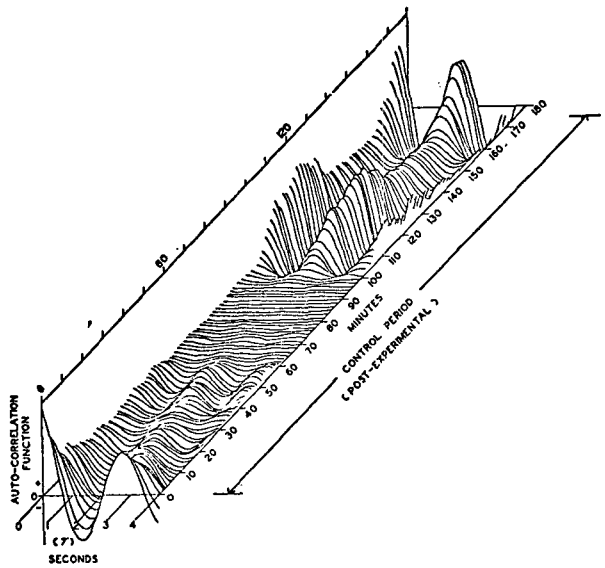

Figure 8. Sequential ACF of Rabbit Respiration Under Control Conditions Following Exposure to 50, 100, and 150 ppm NH_3 in Air