

The Impact of Improved Air Quality on Productivity and Health in the Workplace

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Summary: *We monitored the effect of combined negative ionization and air filtration units on the health and productivity of 1159 office, control room and call-centre staff working in eight different locations. Substantial reductions in sickness symptoms, sickness absenteeism and staff turnover were recorded with significant improvements in productivity.*

Keywords: *negative ions, ionization, air processors, air filtration*

1 Introduction

A substantial body of research data has been published over the past 70 years relating to the health and performance effects of two components of indoor air often overlooked in workplace studies: air-ions and airborne particulates. A broad range of physiological responses are attributed to these factors: respiratory function, stress conditions, hormonal balance, immune response, skin conditions, wound healing, concentration and mood - there is also mounting evidence that negative ions have a biocidal capability. But is there sufficient evidence for professionals concerned with the productivity of work-forces to look beyond the temperature, humidity and refresh rate of indoor air?

In 1933 Tchijewsky demonstrated that rats kept in a well-ventilated cage from which all ions had been removed, died within 2 weeks¹. The experiment was repeated recently by Goldstein, using modern ion generators, with the same result. Tchijewsky concluded that without ions we could not absorb oxygen in the quantities necessary to live and there is increasing evidence from long-haul flights to support this. Whatever the explanation, that simple demonstration tells us quite categorically that ions have biological effect and are absolutely essential to life. Having evolved in an ionized atmosphere over millions of years it is understandable that humans, suddenly denied negative ions in sealed man-made environments, display symptoms of ill-health and distress. It is also interesting to note

¹ A L Tchijewsky, Transaction of Central Laboratory Scientific Research on Ionification (The Commune, Voronej, 1933)

that those symptoms broadly coincide with those adopted by the World Health Organization as indicators of Sick Building Syndrome.

Dr Hawkins at Surrey University noted that the ability of his students to perform high-concentration psycho-motor tasks in a controlled environmental chamber was impaired when the negative ion density was reduced to the level typically found in modern offices². He subsequently conducted a series of trials in working offices³ and found that restoring natural levels of negative ions and reducing particulate levels produced a large reduction in complaints of illness and reduced the incidence of headache by up to 78%. There were also significant "increases in alertness and freshness, with an improved sensation of comfort and pleasantness".

Whilst conducting these trials Dr Hawkins made an interesting finding – that the beneficial effects on staff of cleaned and negatively ionized air persisted for a considerable period following exposure. There has never been any evidence to suggest that such extended benefits are attributable to reduced levels of airborne particulates, but this phenomenon does comply with an established effect of air ions on mammalian body chemistry, researched simultaneously but quite independently by Professor F G Sulman⁴ in

² LH Hawkins & T Barker, 'Air Ions & Human Performance' ERGONOMICS, 1978, VOL. 21, no. 4, 273—278

³ LH Hawkins, 'Air Ions & Office Health', Building Services & Environmental Engineer, April 1981

⁴ F. G. Sulman, D. Levy, L. Lunkan, Y. Pfeifer and E. Tal, 'Absence of Harmful Effects of Protracted

Jerusalem and Prof A P Krueger⁵ at Berkeley. Both researchers reported a direct correlation between the density and balance of air ions in the respirable atmosphere and the blood levels of various hormones, principally serotonin and histamine. Low levels of negative ions are associated with raised blood levels of these neuro-transmitters, whilst enhanced levels of negative ions have a normalizing effect which can persist for extended periods. This so-called 'lag-effect' of ions is, we believe, one of the main reasons why many cross-over trials have failed to show benefit, when earlier uncontrolled trials have given encouraging results. As a consequence it must now be accepted that these trials were fundamentally flawed.

Other trials have failed through an omission to measure ion concentration and therefore being unaware that some products marketed as ionizers do not emit ions. In all of our trials, however, we measured ion concentration using a Medion Atmospheric Ion Analyzer type 134B.

2 Method

British Telecom's policy of continuous improvement in workplace health and productivity provided us with an opportunity to conduct a series of studies over a 6 year period. Air quality has long been a common source of complaint by staff, with dissatisfaction ratings of 70-80% being normal. Previous studies by our team in the early 1990's had confirmed Dr Leslie Hawkins's findings that the ion and particulate content of the air had a major effect on staff health and performance. Air processors - combined ionizer and air filtration units - and ion measuring instruments were provided by Air Ion Technologies, who had also supplied Dr Hawkins for the majority of his trials.

Our studies used the WESTRA symptom scoring system developed by John Jukes and Prof Derek Clements-Croome from the principles used in a number of major studies of Sick Building Syndrome, including Wilson & Hedge (1987)⁶ and G J Raw of the UK

Building Research Establishment⁷. The system comprises a list of 19 symptoms and the question is confined to whether any of those symptoms have been experienced in the previous four weeks.

The responses were obtained by direct interview in order to avoid discussion between staff members and were recorded on a form, with experiences of unusual severity or frequency noted separately. Staff were assured of confidentiality to remove any fears that admissions might prejudice job prospects. Symptoms which staff felt were due to other causes were included with a note accordingly as investigations of such symptoms have often revealed an environmental cause. For example, asthma symptoms experienced from childhood have been known to disappear following our interventions.

Sample sizes were determined to provide a 95% probability at +/- 5% accuracy.

All of our trials used the same Air Processors, units which pass the air through a series of charged, pleated and activated carbon filters and then add negative ions to the recycled air. Ions are a natural component of outdoor air, being molecules of the respirable gases which have either lost or gained electrons due to the ionizing action of cosmic rays, solar radiation, UV, lightning, etc. These natural processes endow each milliliter of clean country air with approximately 1500 negatively charged and 1800 positively charged ions. The proportion of negative ions increases with altitude, under the influence of the earth's electric field, with alpine air containing as many as 10,000 negative ions/ml.

Because airborne particulates act as condensation nuclei for ions, city air tends to be ion depleted but the main losses occur when ion charges are lost within the earthed metal ducts, heat exchangers and grilles of ventilation systems or through attraction to surfaces such as carpets, furnishing fabrics, ceiling tiles and laminated desk-tops, which typically carry a positive static charge. Negative ion levels in sealed, mechanically ventilated offices typically fall as low as 50 ions/ml, with many naturally-ventilated buildings not much better at approximately

Negative Air Ionization'. Int. J. Biometeor. 1978, vol. 22, number 1, pp. 53-58.

⁵ Krueger, A. P. and E. J. Reed (1976). "Biological Impact of Small Air Ions." Science 193(Sep): 1209-1213.

⁶ Wilson & Hedge (1987) *A Study of Building Sickness*, Building Use Studies/ Office Environment Report

⁷ GJ Raw, Building Research Establishment. LAC No 75/1 Sick Building syndrome

250 ions/ml – the only natural parallel being immediately prior to a thunderstorm when the earth's field is severely disrupted.

Air processors use a high voltage corona discharge technique to generate negative ions and in our studies we aimed to maintain minimum concentrations of 2000 neg.ions/ml throughout the trial area. These particular units⁸ are 100% free of ozone and nitrous oxides. Negative ions attach themselves to airborne particulates and accelerate the speed with which they settle out. The overall reduction in respirable particulates – both organic and inorganic – is usually in excess of 90% in a busy working environment. Raising the negative ion level also results in the neutralization of static charges which have been linked to skin rash.

It has long been suggested that negative ions may also exert a lethal effect on micro-organisms and recent work by Leeds⁹ and Southampton Universities, using the same Air Processors, has confirmed that this does indeed occur with at least some infectious agents; and other organisms are slowly being added to the list. In analyzing the results of our various studies, it seems probable that the precipitation of particulates and micro-organisms from the air, together with the biocidal effect account for the high reductions in infection rate.

3 Results

Our trials attempted to quantify the extent to which short-term exposure to unnaturally low levels of ions and the accompanying high level of particulates, typical of many modern working environments, impairs human health and performance and the degree to which this could be economically ameliorated by artificially generated negative ions.

As can be seen in the table, 10 of the indicators were those identified by the World Health Organization as being the common symptoms of Sick Building Syndrome. They include

⁸ Air Ion Technologies Ltd, www.airiontechnologies.com

⁹ K G Kerr, C B Beggs, S G Dean et al; 'Air ionization and colonization/infection with methicillin-resistant Staphylococcus aureus and Acinetobacter species in an intensive care unit'. Intensive Care Med (2005) DOI 10.1007/s00134-005-0002-8

breathing difficulties or wheeziness, sore throat, dry throat, cold or flu-like symptoms, rashes or itches, tiredness or fatigue, blocked or runny nose, dry itchy or tired eyes, coughs and/or sneezes, headaches which we classified as Environmental Stress; and sleeping difficulties, short-term memory, concentration problems, depression/pessimism and irritability/tension which we classified as General Stress. The results revealed the percentage of staff experiencing each of the symptoms before and after the Air Processors were activated. Absenteeism resulting from these symptoms was also recorded.

Four of the trial sites listed in the table belonged to BT and four were studies conducted in the UK premises of other household-name organizations, utilizing the same trial procedures and Air Processors. It is clear that the studies display a surprising consistency of before and after symptom patterns despite a variety of building structures, air handling systems, interior furnishings and types of activity.

3.1 Sickness Symptoms

Results to date involve a total of 1159 subjects and show an overall 57% reduction in reported Environmental Stress symptoms at work, 59% reduction in the five respiratory stress symptoms and 71% reductions in headaches. The ionizers also made a major contribution to a 38% reduction in General Stress symptoms and a reduction in sickness absence in excess of 35%.

3.2 Staff Productivity

In addition to absenteeism figures and symptom scores we studied other aspects of performance in the different sites, reflecting the various commercial concerns of our clients. In one call-centre with 124 staff we monitored call response over a nine month period and ascertained that following our interventions calls answered per day increased by 3.74% and that the average call handling time was reduced by 1.7%. An additional 4.8% saving derived from the fall in sickness absenteeism. A productivity improvement equivalent to 10.5 additional staff was therefore achieved. Productivity results ranged between 5-15%, the variation, we believe, reflecting the commitment of the various executive teams, HR departments and line managers to understand and realize the full productivity potential.

3.3 Underlying Physiology

We were interested to discover whether we could detect any underlying physiology which might indicate how the ions were exerting their influence. During earlier trials involving 4 companies we measured substantial, beneficial changes in the following areas, with no indications of adverse effects:

Blood Pressure	reduced by 14%
Heart Rate	reduced by 19%
Muscle Tension	reduced by 29%
Fatigue (Flicker Fusion)	reduced by 39%
Reaction Times	reduced by 48%
Grip Test	increased by 32%
Skin Resistance	increased by 43%

These figures support the independent findings of Professors Sulman¹⁰ and Krueger¹¹ that negative air ions have a normalizing effect on blood levels of the 'stress' hormone serotonin, on the EEG and the ECG.

3.4 Staff Turnover

Other significant results from the BT sites were a 30% reduction in the turnover of new staff during their first 12 months with the company, attributable to ionization and other environmental improvements.

3.5 Table of Results

ANALYSIS OF ALL SITES

Environmental Stress	Due to Ionisation %		
	Before	After	Impr
Breathing Difficulties	275.3	90.6	67.1
Sore Throat	474.3	197.9	58.3
Dry Throat/Thirsty	834.4	497.2	40.4
Cold Or Flu Like Symptoms	681.9	270.4	60.3
Rashes Or Itches	437.8	285.8	34.7
Tiredness/Fatigue	1019.5	495.0	66.0
Blocked Or Runny Nose	740.5	324.5	56.2
Dry, Itchy Or Tired Eyes	863.4	330.6	73.2
Cough/Sneezing	808.6	391.8	51.6
Headaches	745.0	302.6	71.6

¹⁰ F. G. Sulman*, D. Levy, L. Lunkan, Y. Pfeifer and E. Tal, 'Absence of Harmful Effects of Protracted Negative Air Ionization'. Int. J. Biometeor. 1978, vol. 22, number 1, pp. 53-58.

¹¹ Krueger, A. P. and E. J. Reed (1976). "Biological Impact of Small Air Ions." Science 193(Sep): 1209-1213.

General Stress	Part Due To Ionisation %		
	Before	After	Impr
Sleeping Difficulties	581.8	390.3	32.9
Short Term Memory	427.1	285.0	33.3
Concentration Problems	607.5	383.0	37.0
Depressed / Pessimistic	482.0	268.6	44.3
Irritable / Tense	904.2	529.2	41.5

4 Conclusions

The Leeds hospital trial demonstrated that air processors can provide a high level of protection against even multi-resistant organisms and we conclude that the reductions in coughs, colds and flu-like symptoms achieved in our office studies, were attributable both to the removal of particulates and infectious organisms from the air and to the biocidal action of negative ions. We have demonstrated that indoor environments need enhanced levels of negative ions if the occupants are to remain healthy and perform effectively, and it is in the best interests of every organization to ensure that such levels are provided and maintained.

The combination of negative ion enhancement and particle reduction should be recognized as an extremely cost-effective means of enhancing health and productivity in indoor workplaces.

5 Appendices

CONCENTRATION/TIREDNESS/FATIGUE :

1. Hawkins at Surrey noted the effect of air ions on the ability of students performing high concentration psycho-motor tasksⁱ; negative ions provided up to 29% improvement over normal indoor air-ion conditions.
2. Researchers in Hungaryⁱⁱ recorded a 20% reduction in road traffic accidents when ionizers were fitted in public service vehicles.
3. Bankers in South Africaⁱⁱⁱ reported an 80% reduction in data-entry error-rate after their offices were equipped with ionizers.

HEADACHES:

1. In a further study in the offices of the Norwich Union Insurance Group^{iv} Hawkins recorded a 62% reduction in daytime headaches and a 79%

- reduction during the night shifts, with enhanced negative ion levels.
2. In his study of 1000 Air Ion Technologies Ioniser Users^v, Dr Hawkins noted that 76% of subjects suffering from migraine and 74% suffering headaches reported complete or substantial relief.
 3. Dr Peter Fox, a GP working in the Dorchester area, specialized for many years in the treatment of migraine headaches with negative ions. He finally developed a 10-point questionnaire to ascertain in advance whether a patient was likely to respond to negative iontherapy.

DEPRESSION/TENSION/MOOD:

1. In the Norwich Union office study Hawkins also noted significant improvements in subjective ratings of optimism/pessimism, pleasure/irritability, comfort/discomfort.
2. In the 1000 Ioniser User Trial 79% of those who had bought an ionizer for anxiety or depression claimed to have received complete or substantial relief.
3. In Argentina^{vi} 78% of hospitalized patients suffering from acute anxiety and neurosis achieved complete relief when treated with negative ions alone.

RASH/ITCH/SORE EYES:

1. Norwegian researchers^{vii} investigating incidence of skin rash and sore eyes amongst computer operators established that the static screen charge present on VDUs had the effect of accelerating electrically- charged particles towards the operator, impinging deep into the skin and coating the surface of the eye with abrasive material. Neutralizing the static charge with a negative ionizer relieved the symptoms.

INFECTIONS:

1. Prof A P Krueger writing in Science^{viii} reported on decades of biological research during which time he had noted a lethal effect of negative ions on a wide range of micro-organisms.
2. Veterinary researchers in Helsinki^{ix} demonstrated the ability of negative ions to halt the transmission of a virus

infection between adjacent cages of chickens.

3. A recent trial at St James's University Hospital, Leeds^x, funded by a grant of £101,000 from NHS Estates, reported how air cleaner/ionizers from Air Ion Technologies halted a long-standing history of multi-resistant *acinetobacter* infections in the Intensive Care Unit. The ward has been free of such infections for four years although in adjacent, untreated wards they continue unchecked.
4. Subsequent work by micro-biologists at Southampton University^{xi} confirmed that negative ions have a lethal effect on exposed colonies of *acinetobacter* and *e-coli*.
5. A joint application by Southampton University and Southampton General Hospital for £85,000 to fund further research into this potential solution to hospital acquired infections has received provisional approval from the Department of Health.
6. Prof A P Kruger writing in Science¹⁰, reported on a Swiss bank that had equipped one large department with ionizers where they recorded one day lost to sickness for every sixteen days lost in an equivalent un-ionized area.
7. In the UK, absenteeism from the Surrey Constabulary's M25 control centre was reduced by 81% and aboard the naval frigate HMS Liverpool reports to sick bay were reduced by 91%^{xii}.

RESPIRATORY CONDITIONS

1. Schultz^{xiii} exposed 3000 patients with bronchial asthma to negative ions in his Cologne clinic and reported the following results:

Age	< 20	20-40	40-60	60-80
Complete success	83%	57%	43.7%	40.6%
Considerable improvement	15%	42%	44.6%	50%
No effect	2%	1%	11.7%	9.4%
Adverse Effect	0%	0%	0%	0%
Total benefiting	98%	99%	88%	90%

** Subsequent experience indicates that older patients take longer to display the first signs of response than was possible under Dr Scultz's regime but do derive benefit where they persevere.*

2. Palti^{xiv} working at the Bikur Holin Hospital, Jerusalem, used negative ions to completely relieve spastic bronchitis and bronchopneumonia amongst 19 infants below the age of 12 months, in all cases and within 20 minutes. He subsequently induced bronchial spasm in a group of previously healthy infants through the use of positive ions and relieved them with negative ions.
3. Dr Hawkins^{xv} conducted a postal survey of 1000 home users of Air Ion Technologies personal ionizers with the following percentages reporting total or substantial relief of symptoms:

Asthma	65
Hay fever	71
Catarrh	64
Bronchitis	68
Emphysema	64

The response rate was considered exceptional at 78% and the researchers remarked on the high level of unsolicited accompanying testimonials that expanded on the benefits to health and quality of life, and the total absence of adverse side effects.

THERMAL COMFORT

1. During a pig trial conducted by Agrion, it was noted that the animals displayed an improved ability to regulate their body temperature.
2. Dr Hawkins noted that trial subjects in an ionized environment rated themselves warmer. He subsequently found that the skin temperature of students exposed to negative ions was approximately 1°C warmer with no increase in core temperature. The implication is that indoor air temperature can be reduced by 1°C, representing an 8% reduction in heating energy consumption and costs.

6 References

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 - v L H Hawkins, quoted in 'A Short How & Why of Air Ionization' pub Medion Ltd, (now Air Ion Technologies) 1993
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 - vii Hans H Tjonn MD, Directorate of Labor Inspection, Oslo, cited in *Health Hazards of VDTs?* Ed. Brian Pearce, HUSAT, Loughborough University. Pub Wiley ISBN: 0471 900 65 6
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