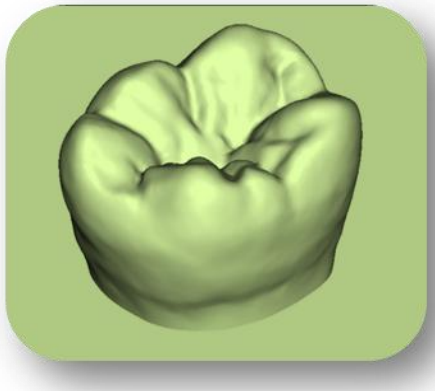
University of Waterloo

# ECO-FRIENDLY DENTISTRY

## THE ENVIRONMENTALLY-RESPONSIBLE DENTAL PRACTICE



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## Executive Summary

The aim of this project was to present tangible data to dentists in private general practice so that the environmental cost of conducting the practice of dentistry would be emphasized. Presented with this data, it is hoped that dentists will be stimulated to take proactive actions using the environmental alternatives presented.

A survey technique was used to create a case study comparing the environmental burden from conventional dental offices to a proposed "green" dental office.

The results indicated that many reasonable, practical and easy alternatives do exist which would reduce the environmental footprint of a dental office were it to follow the "green" recommendations. For example, from our survey conventional dental offices used thousands of sheets of paper per year in excess of a "green" model.

This report concludes that dentists should take a leading role in society by implementing "green" initiatives to lessen their impact on the environment. This report provides a series of "green" recommendations that dentists around the world can implement to become leading stewards of the environment.

## Introduction

"The ultimate purpose of business is not, or should not be, simply to make money. Nor is it merely a system of making and selling things. The promise of business is to increase the general well-being of humankind through service, a creative invention and ethical philosophy." (Paul Hawken, 1993; The Ecology of Commerce)

Environmental awareness and accountability are rapidly moving to the forefront of humanity's consciousness. Naturally, the development of environmentally-responsible practices is increasingly evident. Many businesses are in fact striving to alter their practices by

taking environmental responsibility either voluntarily or due to regulatory pressures.

The healthcare sector is an area not often associated with burdening the environment. Nor should this association be a criterion upon which to base a "green" healthcare movement. In dentistry, particular research interest has been devoted to minimizing the environmental impact from mercury. Aside from mercury, to date there has been relatively little reported on dentistry's other environmental pollutants. Excluding mercury, this report will outline many other environmentally-friendly alternatives and practices that can be implemented. "This sustainable approach to dentistry incorporates ecologically sustainable materials and practices that reduce the impact of medical procedures on the environment as well as protecting clients from toxic materials" (Desai, 2003-2006, p.17).

Most dental offices are privately-owned small businesses and have no financial advantage to invest in many environmentally-friendly practices. There are no funds or grants available to assist in making an office "green". It is essentially up to the consciousness of the business owner. "Setting out to redesign or start up a business so that it does maintain a holistic relationship between economy and ecology, the ethical entrepreneur is handicapped financially since he bears the costs of the additional responsibilities he's assumed." (Paul Hawken, The Ecology of Commerce, 1993). For this reason, more research is needed to find cost-effective environmental alternatives in dentistry.

## Purpose Statement of Project

The purpose of this project is to raise widespread awareness of environmental alternatives in the dental community and to stimulate action based on the recommendations made. This is achieved by first assessing the typical environmental impact from five dental offices. Comparisons are then made to one possible "green" model using a methodological approach based on quantitative and qualitative

research. A "green" list of practical eco-friendly recommendations will then be generated. This will facilitate the adoption of positive changes to minimize dentistry's environmental impact and to promote a leading role for dentistry in environmental stewardship. As such, this project is intended for the consumption of both the dental and the general community.

## Boundaries of Project

The scope of this project will be limited to three dental offices in the City of Waterloo, one dental office in Haldimand County, one dental office in the City of Oshawa and one future dental office in the County of Perth that will begin its operation in the spring of 2007. The data will be collected over a typical work week. This research will *exclude* the environmental impact from the use of mercury in dentistry. Given the small scale of this project, both in terms of funding and manpower, this project is meant to be an initial foray into the area of eco-friendly dentistry.

## Target Audiences

A variety of eco-dentistry guidelines and alternatives will be presented in this paper. It is our intention that these "green" recommendations be made accessible to each and every dentist in the world. To achieve this, this paper will be submitted to the Journal of the Canadian Dental Association (JCDA) for publication.

## The Importance of Eco-friendly dentistry

It is our belief that there should be no such term as "environmentalists." To refer to a segment of society who cares about the health and welfare of the planet as such is akin to using the term "human rightists" for those who show compassion and offer aid to their fellow human beings.

It has been said that it is not possible to have healthy people on a sick planet. Reducing waste, changing patterns of consumption and limiting the amount of adverse chemicals entering the breathable air of a dental office are achievable and realistic goals. This project will demonstrate that though the non-mercury related environmental impact of dentistry is not abundantly documented, it is nevertheless worthy of the profession's attention.

## Aim of the Study

The aim of the study is to present tangible consumption data (e.g., number of patient bibs used per year) to dentists in private practice so that the environmental cost of routine dental practice can be highlighted. Given concrete data (e.g., number of trees saved), it is hoped that dentists will be catalyzed to adopt if not all, many of the recommendations from the "green" list.

The following four key questions will be addressed in this project:

- By using the "Environmental Assessment Questionnaire," what is the non-mercury related environmental burden from a conventional dental office?
- In comparison, what is the non-mercury related environmental burden from a prospective "green" dental office?
- Based on the obtained results, can eco-friendly dental practices be universally recommended?
- In what ways can a typical dental office implement sustainable environmental practices?

## Background Information on Eco-friendly dentistry

Eco-friendly dentistry is an approach to dentistry that implements sustainable practices by keeping resource consumption in line with nature's economy, by safeguarding the external environment by virtue of eliminating or reducing outgoing wastes and by promoting the well-being of all those in the clinical environment by conscious reduction of the chemicals in the breathable air.

Hiltz (2007) states:

> "Dentistry is a profession dedicated to promoting and enhancing oral health and well-being. To accomplish these goals, dentists use a variety of materials and equipment. Unfortunately, some of the materials that are currently in use – including heavy metals and biomedical waste – present potential challenges to the environment" (p.59).

The Teleosis Institute (2006) states:

> "In Green Health Care, toxic-free buildings, literacy around local environmental health issues, and the use of safe, effective, precaution-based medicine are all intrinsic parts of a new system of healthcare that is good for people and the environment."

## Literature Review

Eco-friendly dentistry is a relatively new term and an emerging concept in dentistry. It is part of a larger movement towards ecologically-sustainable healthcare. In dentistry, a large volume of research has been devoted to the environmental aspects of mercury. And rightly so given that mercury is a significant environmental pollutant.

- Chin G, Chong J, Kluczewska A, Lau A, Gorjy S, Tennant M. Aust Dent J. The environmental effects of dental amalgam. 2000 Dec; 45(4):246-9.

- Arenholt-Bindslev D. Adv Dent Res. Dental amalgam – environmental aspects. 1992 Sep; 6:125-30.

Recently, more attention has been given to other sources of environmental pollutants in addition to mercury.

- Hiltz M. J Can Dent Assoc. The environmental impact of dentistry. 2007 Feb; 73(1):59-62.

More recently, the term "Eco-dentistry" has been pioneered which has taken dentistry beyond the point of preventing pollution to a place of promoting sustainability.

- Pockrass F, Pockrass I. Journal of Ecologically Sustainable Medicine, Symbiosis, 17. "Eco-dentistry": A model of mercury-free dentistry.

To date, there has been no published data on the quantitative benefits of an eco-friendly approach to dentistry. It is an accepted social meaning that to act environmentally sound is preferable to being an ecological liability but how much difference is it really making if an office recycles paper, plastics and uses energy-efficient lights? Can a valid comparison be made between conventional models and a new "green" one?

That is precisely the research objective of this paper. We believe this is the first published investigation of its kind. Given the limited financial and human resources of this project, it is meant to be an initial attempt to derive quantitative data, however limited in its scope.

The area of eco-friendly dentistry is in great need of more research in the area of economical analysis of traditional versus a "green" dental model. Furthermore, many of the survey items may be expanded into individual research projects.

## Methodology

- All dental offices are in Ontario, Canada.
- Five conventional dental offices were selected.
- Three of the five dental offices were in the Region of Waterloo.
- One was in Haldimand County.
- One was in Oshawa.
- The "green" dental model will be in the County of Perth.
- Reasons for choosing the five dental offices:
    - Convenience
    - Locality
    - Conventional

Dr. Farahani chose to survey two dental offices with which he was familiar. I chose to survey three dental offices because of locality. I do not have access to a car in Waterloo. Therefore, I had to choose the dental offices close to where I lived. The purpose was to choose five conventional dental offices and in the end, that purpose was achieved.

**Research Approaches:**

- Questionnaires
- Interviews
- Five interviews were conducted. I surveyed three dental offices in the Region of Waterloo. Dr. Farahani surveyed two dental offices.
- The basic purpose of using the "Environmental Assessment Questionnaire" to conduct interviews was to understand the consumption patterns of five conventional dental offices so that a thorough comparison can be made between a conventional and a "green" dental practice.

The data was analyzed according to the following criteria:

- The data was divided into two categories such as qualitative and quantitative. Any question with a mathematical output was classified as quantitative. On the other hand, any question that required secondary research to explicate its purpose was classified as qualitative.

**For example:**

Average number of papers in a typical chart is an example of a specific question because I had to make an average calculation based on five numerical values I had from the data I collected for this question.

The discussion of flooring types is an example of a generic question because secondary research was used to determine benefits and costs of various clinical flooring.

Furthermore, the data was divided into three main categories: consumption, breathable air, and waste management. Each of the questions was placed in one of these categories. "Green" alternatives were proposed for each category.

The research went very well. Initially, I contacted more than 10 dental offices in the Region of Waterloo. I collected a booklet that contained contact information of dental offices in the Region of Waterloo from the University of Waterloo's Dental Plan Office. Based on that, I contacted dentists randomly by phone. I gave them a brief introduction about who I am, why I am calling, and what the purpose of the study is. Almost all of the dental offices I contacted were extremely receptive because they were keen on helping me out as this project was a critical requirement at the University of Waterloo. On the whole, they were helpful and I did not have any problems.

**Advantages and Limitations of the chosen research approach:**

I divided my research approach into two main categories:

- **Primary research:** questionnaires and interviews
- **Secondary research:** literature review

**Benefits of Interviews:**

- Create an interactive forum for the assessment of interpersonal skills, job-relevant knowledge, motivation and potential fit
- Allow the interviewer to:
  - Sell the organization to qualified candidates
  - Give a realistic and detailed description of the position to candidates
- Interviewer can obtain supplementary information
- Quick and cheap if the sample is small
- Verifiable by replication and re-questioning of interviewees/respondents

**Limitations of Interviews:**

- Poor reliability/consensus between different interviewers
  - Different interviewers have their own styles and approaches
  - Vary in how many criteria they assess
  - Vary in the standards they use to assess and weight criteria
- Poor validity/prediction of job performance
  - Interviews are not very good predictors of job performance

- Intrinsic limitations of the interview
  - Higher degree of subjectivity
- Interviewer biases
- Interviewer errors
- Subjective evaluations are made
- Not much evidence of validity of the selection procedure
- Not as reliable as tests
- Time consuming if sample is large
- Closed questions may constrain the data
- Respondents may interpret the questions differently
- Response rate may be low and selection non-random

**Source:** Dattner Consulting, LLC (Ben Dattner, Ph.D.) and http://www.hr-guide.com/data/G311.htm

**Literature Review:**

- A literature review is an account of what has been published on a topic by accredited scholars and researchers.
- Purpose is to convey to the reader what knowledge and ideas have been established on a topic, and what their weaknesses and strengths are.

**Source:** http://www.utoronto.ca/writing/litrev.html

**Advantages:**

- Accessible
- Helps to examine large-scale trends

**Disadvantages:**

- Lack of consistency of perspective
- Biases and inaccuracies cannot be checked

## Results

| Consumption | Dental Office 1 | Dental Office 2 | Dental Office 3 | Dental Office 4 | Dental Office 5 | Average | Dental Office 6 (Green Model) |
|---|---|---|---|---|---|---|---|
| Average # of patients seen per day | 30 | 26 | 25 | 31.6 | 15 | 25.5 | 16 |
| Average # of papers in a typical chart | 6 | 20 | 6 | 13.3 | 16.2 | 12.3 | 6 |

| Waste Management | Dental Office 1 | Dental Office 2 | Dental Office 3 | Dental Office 4 | Dental Office 5 | Average | Dental Office 6 (Green Model) |
|---|---|---|---|---|---|---|---|
| Average # of autoclave bags used per day | 20.0 | 12.5 | 6.0 | N.A | 55.0 | 23.4 | 16 |
| Is paper from autoclave bags recycled? | No | No | N.A | No | Yes | N.A | Yes |
| Is paper recycled? | Yes | Yes | Yes | No | Yes | N.A | Yes |
| Average # of patient lbs/day | 30 | 26 | 25 | 31.6 | 15 | 25.5 | N.A |
| Is recycled paper used? | Yes | Yes | No | No | No | N.A | Yes |
| Are patient lbs 2-ply or 1-ply? | 2-ply | 2-ply | 2-ply | 2-ply | 1-ply | N.A | N.A |
| Is plastic from autoclave bags recycled? | No | No | No | No | Yes | N.A | Yes |
| Electricity consumption as per one load of wash | N.A | N.A | N.A | N.A | N.A | N.A | Washer |
| Is developer solution recycled? | Yes | No | Yes | Yes | Yes | N.A | N.A |
| Is fixer solution recycled? | Yes | No | Yes | Yes | Yes | N.A | N.A |
| Electricity consumption as per one load of dry | N.A | N.A | N.A | N.A | N.A | N.A | Dryer |
| Are biohazards managed by a biohazard company? | Yes | Yes | Yes | Yes | No | N.A | Yes |
| How many garbage bags (10L) are filled/day? | 10 | 6.7 | 3 | N.A | 6.7 | 9.35 | N.A |
| Is lead foil from x-rays recycled? | Yes | Yes | Yes | No | No | N.A | N.A |

| Types of light bulbs | Fluorescent | Fluorescent | Fluorescent & Halogen | Fluorescent & Halogen | Fluorescent | N.A | Fluorescent (where practical) |
|---|---|---|---|---|---|---|---|
| Types of screens | CRT-Tube | LCD-Flat Panel | LCD-Flat Panel | LCD-Flat Panel | CRT-Tube | N.A | LCD-Flat Panel |

| Breathable Air | Dental Office 1 | Dental Office 2 | Dental Office 3 | Dental Office 4 | Dental Office 5 | Average | Dental Office 6 (Green Model) |
|---|---|---|---|---|---|---|---|
| What type of surface disinfectants are used in the office? | Cavi Wipes | Biosurf and Chaircare | Cavi Wipes | Germ Extra | Biosurf, Biotext, Cidex lines | N.A | SOL-U-GUARD |
| Type of flooring in non-clinical areas | Rugs | Marmoleum | Carpet/Rugs/Linoleum | Rugs | Rugs | N.A | Hardwood |
| Type of flooring in clinical areas | Vinyl | Linoleum | Linoleum | Vinyl | Linoleum | N.A | Linoleum |
| Type of paint | VOC Latex | VOC Latex | N.A | VOC Latex | VOC Latex | N.A | Ultra-low VOC Latex |

## Analysis and Discussion

**Volume and Conversion Scale:**

Every private general dental office has a differing volume of dental services rendered. This volume depends ultimately on the number of dental patients treated per day. To make our data more meaningful to all private dental offices, we chose a baseline volume of patients such that any dental office could create a simple conversion scale to make the results of this study approximately

comparable to their own situation. In the "green" model, a baseline of 16 patients treated per day is used. Therefore, if an office services on average 32 patients per day, they can divide their consumption data by 2 for purposes of comparison to the "green" model.

**Consumption:**

**Paper**

1. **Average number of papers in a typical chart**

   The average number of papers in a typical chart between the five conventional dental offices is 12.3. The "green" model would use 6 papers in a typical chart. The difference between the dental offices is 6.3 (12.3 - 6). For a 2000-chart dental office, at any one time 12,600 papers can be saved in a digital office.

   This corresponds to the following:

   According to Save-A-Tree, "Environmental savings for using 151 Lbs. of Save-A-Tree paper" include:

Trees Saved

1

Wood Saved (Lbs.)

523

Water Saved (gals.)

770

Landfill Reduced (Lbs.)

82

Net Greenhouse Emissions Reduced (Lbs.)

158

Energy Reduced (BTU) (000)

1,042

**Source:** http://www.unisource.ca/misc/sat/en/eco.php

**2. Average number of autoclave bags (e.g. Statim) used per day**

In the survey, the average number of autoclave bags used per day is 23.4. Given a 200-day work year, that amounts to 4,680 (23.4 * 200) pieces of autoclave paper. One of the offices we surveyed recycled these bags using the standard "Blue Bin" program. Since these bags are sterilized and carry sterilized instruments up to the point of being discarded, there are no biohazard concerns.

The "green" model would use an Instrument Cassette Management System (Hu-Friedy IMS) that enables washing (Hydrim, Scican) and sterilizing (LISA, A-dec) the instruments. Traditionally, cassettes have been packaged with disposable autoclave wraps (Hu-Friedy). The "green" model proposes an innovative, eco-friendly alternative:

- Once the cassettes have been washed, operating room (O.R.) cotton towels (Medimart) are used to wrap the cassettes. The wrapped cassette is placed in an appropriately-sized autoclave bag (Medimart) and placed in the autoclave (see Appendix). This process allows the O.R. cotton towel to be sterilized *as well as* the cassette and its contents. The autoclave bag is necessary to ensure that the vacuum phase of the autoclave does not remove the micro-fibers from the O.R. cotton towels. These micro-fibers have been shown to cause serious damage to autoclaves. Upon completion of the sterilization, the autoclave bag is carefully opened to separate the paper and plastic portions without tearing if possible. Accordingly, the paper and plastic portions are recycled using neighbourhood Blue Bins. The wrapped cassettes are then stored appropriately for eventual usage while maintaining their sterilization status as they would with disposable autoclave wraps.

None of the offices in the survey used the disposable autoclave wraps (e.g. 'blue' wraps from Hu-Friedy), so we have no data to report, however, it is reasonable to correlate the number of disposable autoclave wraps to the number of autoclave bags (e.g. ones used in Statim). A rough assumption is made that one patient requires one set of instruments contained in one autoclave bag. That is, using this system, 4,680 disposable (blue) autoclave wraps are not sent to landfills each year. In a thirty-year career, that is an environmental saving of over 140,000 wraps. This saving is not only in terms of landfill burden but also of associated resources, such as water, electricity and trees to name a few.

It is important to note that following this eco-friendly sterilization protocol, ten out of ten spore tests (3M Comply SteriGage) have demonstrated complete sterilization in a variety of cassette sizes from small exam kits to larger oral surgery cassettes.

**3. Average number of patient bibs used per day**

One conventional patient bib comprises of 1 or 2-ply (or even 3-ply) paper plus 1-ply plastic. The average number of patient bibs used per day between the five dental offices is 25.5. For a 200-day work year, 5100 (200 * 25.5) pieces of paper are consumed and discarded into land fills each year of practice. Due to biohazard contamination, these papers are not recyclable and thus directly contribute to landfills. In addition, it is not readily possible or practical to separate the plastic from the paper. Consequently, over a 30-year career, over 150,000 bibs (paper and plastic) will burden landfills (see Appendix).

The "green" model would not use patient bibs. As mentioned above, O.R. cotton towels are used to wrap the instrument cassettes throughout the sterilization process and serve as a

sterile packaging for the cassettes awaiting usage. Each patient seen will require an instrument cassette which comes wrapped in an O.R. cotton towel which can now serve as the patient bib. After the patient's visit, the soiled O.R. cotton towel is appropriately stored as soiled laundry. Then the O.R. cotton towels may be washed and dried using a heavy-duty washer and dryer either on-site (using eco-friendly laundry agents) or through a laundry service. The cleaned and dried O.R. cotton towels will re-enter clinical service at the point of serving as a wrap for the washed instrument cassette. At this point, they are bagged with the cassette and sterilized, ready for clinical use again.

4. **Are paper bibs 2-ply or 1-ply?**

   If the paper bibs are 2-ply, then 10,200 pieces of paper will be discarded into landfills each year, over 300,000 in a 30-year career.

**Electricity**

1. **Electricity consumption as per one load of wash**

   The environmental trade-off for not using paper bibs is the need to use electricity, water and cleaning agents for the O.R. towels in the process of washing them. The other five dental offices are not using these resources for this purpose. However, electricity, water, trees and other resources are used to make paper bibs, though these are 'hidden' consumables in the ever-consuming society in which we live. The "green" model would be

using an Energy Star washer (Kenmore Elite E3 3.8 Cubic Feet Washer).

**2. Electricity consumption as per one load of dry**

In the same way, the "green" model would need to use a dryer. A conventional dental office does not need to use a dryer. Here only electricity and not water and cleaning agents are being consumed. The "green" model would be using an Energy Star dryer (HE4 Kenmore 7.0 Cubic Feet Front Load Dryer).

**3. Types of light bulbs**

The conventional dental offices use fluorescent and halogen lighting. The California Energy Commission states, "Although some halogens use up to 20 percent less energy than incandescent lights and last anywhere from 2,000 to 6,000 hours, they are far less efficient than compact fluorescents." According to BC Hydro, "High-efficiency fluorescent lighting can reduce lighting energy costs by up to 75%." Similarly, GreenCulture Lighting indicates, "Compact fluorescents use about 65% less energy than standard incandescent light bulbs and last 10-20 times longer." Greenpeace International states, "Compact fluorescents use four times less energy, and last eight times longer (8,000h instead of 1,000h) than incandescent light bulbs."

| Incandescent | | Fluorescent | | | Wattage |
|---|---|---|---|---|---|
| Watts | Lumens | Watts | Lumens | Type | Reduction (%) |
| 25 | 230 | 9 | 400 | bare lamp | 64 |
| 40 | 460 | 11 | 600 | bare lamp | 72 |
| 60 | 890 | 15 | 900 | bare lamp | 75 |
| 60 | 890 | 17 | 950 | with diffuser | 72 |
| 75 | 1,200 | 20 | 1,200 | bare lamp | 73 |
| 75 | 1,200 | 23 | 1,550 | bare lamp | 69 |

**Source:** http://oikos.com/library/eem/cfl/savings.html and http://www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Lighting_Technology_0606.pdf

The "green" model would employ fluorescent lighting wherever practical. Care must be taken in using compact fluorescent lighting in areas where a common mishap could result in a fracture of the bulb and possible release of mercury from inside the bulb. In addition, these bulbs must be properly recycled.

**4. Types of computer screens**

The conventional dental offices use Cathode-Ray Tube (CRT) and Liquid Crystal Display (LCD) computer screens. The "green" model would employ LCD screens. The energy consumption of CRT versus LCD computer screens is as follows:

**Energy Consumption**

| Power Consumption Parameter | CRT Monitor | LCD Monitor |
|---|---|---|
| **Average consumption** | 76 W | 20 W |
| **Screen colour sensitivity** | Extremely sensitive. Consumes lot more power (43% more) when displaying white on screen. | Completely insensitive. Consumes same power for all colours on screen. |
| **Brightness setting sensitivity** | Moderately sensitive. Consumes more power at higher brightness. | Sensitive. Consumes higher power for higher brightness. |
| **Contrast setting sensitivity** | Less sensitive. (Almost insensitive when brightness setting is low.) | Completely insensitive. Consumes same power for all contrast. |
| **Consumption when turned off from computer power settings** | 2 W | 0 W |

**Source:** http://savingenergy.wordpress.com/page/2/

## Water

1. **Type of dental vacuum pump**

   There are three types of dental vacuum pumps: 'water-consuming', 'water-recycling' and dry. In our survey, water-consuming and water-recycling, collectively termed 'wet' vacuum pumps are used. We were not successful in distinguishing which of the two 'wet' vacuum pumps are used in a given dental office. The "green" model would use a dry dental vacuum pump.

2. **Water usage from dental vacuum pump**

   "Water usage can be reduced through use of a water recycler, which recycles much of the liquid back through the pump, adding fresh water to it. Water recyclers can reduce water usage by approximately 80%. A typical one horsepower water-ring pump for a small facility with a recycler uses approximately **15 gallons of water per hour.**" A 'dry' vacuum pump uses no water.

**Source:**
https://decs.nhgl.med.navy.mil/DMNOTES/dentalvacuumsystems.pdf

The eco-friendly model saves over 1,600 gallons of water per year, or roughly the equivalent of 12,000 500ml-bottles of fresh potable water using a dry dental vacuum pump as opposed to wet and water-recycling dental vacuum pumps used by conventional dental offices.

Given the **severe waste** of clean water resulting from 'water-using' and to a lesser extent the 'water-recycling' vacuum pumps, it is a strong recommendation of this paper that clinics switch to dry vacuum models. The economic savings from such enormous reduction in water consumption would be an interesting investigation, one which is beyond the scope of this paper.

**3. Water consumption as per one load of wash**

"Washing one load of clothes in an automatic washer uses about 45 gallons."

**Source:** http://www.aguasolutions.com/facts.html

"Washing machines can account for as much as 20 % of the electricity you use."

"Use Cold water, as almost 90 % of the energy consumed by washing machines goes to heating the water. Set the washing machine temperature to cold or warm and the rinse temperature to cold as often as possible."

**Source:**
http://www.bharatpetroleum.com/wheels/fuelConservationTips.asp?from=wheel

## Plastics

1. **Average number of autoclave bags (e.g., Statim) used per day**

   Offices using autoclave bags are encouraged to use their local Blue Bin recycling program. From our survey, this would mean that 4,680 pieces of plastic do not end up in the landfill each year.

2. **Average number of bibs used per day**

   As outlined above, the "green" model would use O.R. towels, not patient bibs. From our survey, 5,100 pieces of plastic (back of bibs) are consumed each year. This totals over 150,000 pieces of plastic in a thirty-year career. All such plastics contribute directly to landfills, as biohazards preclude the possibility of recycling.

## X-rays

In our survey, all the conventional dental offices used traditional film x-rays. This technology has two significant environmental considerations: silver and lead pollution.

Silver is a heavy metal that can enter our water system if improper disposal of dental x-ray fixer occurs. Discarding used solutions down the drain must and can be avoided. This source of water pollution is a cause of concern that can be easily addressed. There are services for dental offices to recycle used radiographic fixer. Contact the supplier of the fixer about a take-back and recycling program (Hiltz, 2006).

Another common source of silver which can enter our landfills and water systems is undeveloped film. Such items contain toxic untreated silver which can be safely disposed by an approved waste carrier or supplier (Hiltz, 2006).

Lead pollution is another possible outcome of traditional x-rays. Lead is known to have adverse health effects on both children and adults, even at low doses. Like mercury and silver, lead is toxic and persists in the environment (Hiltz, 2006). As with silver, reducing the environmental burden is readily achieved. Lead foil which envelops the actual film must not be disposed to the general waste system. The lead contained in the foil can be leached from the landfills if no leachate collection system is in place (Tsuji et al, 2005). Lead foil packets can be collected in a container that is provided by an approved waste carrier or supplier.

The "green" model would employ digital radiography. As an effective environmental alternative to traditional film-based x-rays, digital x-rays do not employ silver or lead.

1. **Average # of x-rays performed per day**

   It is a great environmental concern if the source of lead contributes to landfills, especially those without leachate collection systems. From our survey, the average number of x-rays taken per day is 21.5. In a 200-day work year, that amounts to 4,300 lead foils consumed. It is encouraging to see that three out of the five clinics in our survey do in fact recycle the lead. It is highly recommended that all dental clinics using traditional x-rays which do not recycle lead begin to implement this important and easy step.

**Chemicals**

Most radiographic developer and fixer solutions contain the following chemicals in various quantities: Hydroquinone, acetic acid, 1-phenyl-3-pyrazolidinone, gluteraldehyde, ammonium bisulphite, sodium bisulphite, and ammonium thiosulphate among others. According to the MSDS of these various solutions, we know that volatile fraction by weight range from 60-90% and higher. There are repeated warnings such as 'Avoid prolonged or repeated breathing of mist or vapour.' and 'Vapour extremely irritating.' In the case of gluteraldehyde we read: 'Although it is known that glutaraldehyde is a respiratory tract irritant and may aggravate pre-existing asthmatic disorders, the supporting data for respiratory sensitization are less conclusive.' (KODAK RP X-OMAT Developer Replenisher, Part C). And for hydroquinone, we are told that 'there is evidence for the clastogenicity (chromosome breakage) of hydroquinone in vivo and in vitro. The relevance of chromosomal effects in test animals in predicting human risk is unclear' (Kodak Developer Replenisher). In addition there are clear warnings of incompatibilities such as "Contact with strong acids may liberate sulphur dioxide (KODAK RP X-OMAT Developer Replenisher, Part A)." and "Contact with base liberates ammonia (KODAK RP X-OMAT LO Fixer and Replenisher, Part A)." These warnings are from chemicals which are very basic (pH 11.4) and very acidic (pH <1) respectively, and very importantly, are intended to work in tandem in one and the same x-ray developer apparatus literally in adjacent receptacles. Given that these chemicals are physically poured into and out of their holding receptacles, given the high volatily, given that they are jointly covered by one lid for the entire apparatus, given that x-ray developer rooms are typically small areas with only one door and no windows, given that a dental operator enters that room multiple times a day, even with proper ventilation, what is the long-term effect of such exposure to a dental personnel over a relevant period of time, twenty years for instance?

To the best of our knowledge, this is a very under-researched aspect of possible workplace pollution in the dental environment. Further research into this area may be warranted.

1. **Average # of developer and fixer bottles used in a month**

   From our survey we found that on a monthly basis, 1.5 bottles (4-L) of each fixer and developer solutions were consumed. Given that the "green" model does not consume these solutions, or actual x-ray film, or many other recurring costs, a long-term cost comparison of traditional versus digital radiography would be an interesting area of investigation. The following link maybe used for this purpose: http://www.idexx.com/animalhealth/digital/cr/economics/index.jsp.

**Breathable Air:**

1. **What type of surface disinfectants are used in the office?**

   In our survey various surface disinfectants were utilized (see Chart under Results). Among these agents used in conventional dental offices, the following are some of the active ingredients: Isopropanol, Butyl Cellosolve, and Hyamine 1622. The occupational exposure limits to Hyamine 1622 have not been established (Caviwipes MSDS). In June 2000, the World Health Organization (WHO) sounded the alarm regarding the rise of drug resistance that threatens to set back the medical advances of the modern age. Their report illustrates that almost all major infectious diseases are gradually but successfully developing resistance to current medicines. Also in June 2000, the Council of Scientific Affairs of the American Medical Association issued a warning that the rampant use of biocides for the purpose of creating a germ-free environment may lead to a suppression of immunity in humans to common disease-causing agents as well as more resistance among

microbes to commonly used biocides (RCDSO, Practice Advisory, April 2002).

Seen in this light, it may be prudent for the dental community to re-examine its current dependency on relatively potent chemical compounds for the routine cleansing of hard surfaces (RCDSO, Practice Advisory, April 2002). The "green" model advocates the use of an alternative disinfectant (Sol-u-guard, Melaleuca), one which utilizes the natural antimicrobial effects of tea tree oil (Carson et al, 2006) and thyme (Schelz et al, 2006).

## 2. Type of flooring in non-clinical and clinical areas

In our survey, we found the following types of flooring used in clinical and non-clinical areas: rugs, linoleum, hardwood, and vinyl.

Vinyl carries with it some unenviable properties with respect to contributions to the breathable air and to the environment as a whole. The following is a summary:

- The manufacturing of vinyl creates poisons including dioxin, vinyl chloride and ethylene dichloride, which can influence the general environment surrounding the production factory.
- Non-renewable petroleum is the basic building block of a plastic such as vinyl. As such the oil required to manufacture vinyl usually travels thousands of miles to get to North America. This makes vinyl a raw material burden and significantly raises its total energy cost.
- In regards to the breathable air, once installed, vinyl may off-gas harmful compounds (such as lead, cadmium and phthalate plasticizers) for years.
- At the end of its useful life, vinyl will not bio-degrade in the landfill. Millions of pounds of vinyl tile are land filled in the United States each year. Alternatively, vinyl

must be burned at very high temperatures to avoid releasing poisonous dioxins.

A common criticism of synthetic carpets is the use of petroleum-based fibers and the resultant off-gassing of volatile organic compounds (VOCs). One option is to use recycled carpeting which is made principally from post-consumer plastic soft-drink containers. Another alternative is to use natural carpets and rugs made from wool, cotton or even grass with minimal processing and treatment, although care must be taken to factor in 'hidden' environmental costs of such natural solutions such as the dyes and bleaches that may be used to treat the wool.

Besides petroleum off-gassing, carpets and rugs are virtually impossible to truly clean and continually accumulate various wastes. In a dental environment, even with very low concentrations of mercury vapour in the breathable air, a carpet is not ideal even in non-clinical areas possibly in a child's play area.

For many people, there is something very warm and inviting about aged hardwood flooring. Furthermore, hardwood floors are excellent for indoor air quality as it off-gases only minimally and does not harbour dust mites or mold. However, wood is still a raw material and its use must be carefully considered. Depleted woods such as North American beech should be avoided. Clear-cutting and over-harvesting are major issues therefore search for wood that has been approved by the Forestry Stewardship Council (FSC) or has been otherwise sustainably harvested. Care must also be taken to use a low VOC sealer. For the non-clinical areas, the "green" model would use a pre-existing aged hard wood floor which would be refinished and sealed with a sealer thought to be low in VOCs.

**Source:**

http://www.greenhomeguide.com/index.php/knowhow/entry/802/C220

While flooring type has a subjective element, an objective analysis of eco-friendly flooring is also possible. A Life Cycle Assessment (LCA) is the best way to measure the environmental impact of floor coverings. From raw materials all the way to recycling and disposal, from effects on global warming to indoor air quality, LCAs chart the environmental impacts of products in every stage of their lives. The exclusion of any elements or impacts invalidates the results.

**Source:**

http://www.forbolinoleumna.com/framework/ModuleFiles/mod_document_url/144/environment%20brochure.pdf.

Linoleum is considered to be viable green alternative to vinyl. In addition to being more eco-friendly, linoleum also has a practical advantage over vinyl. For instance, in linoleum patterns are dyed straight from the top through to the backing, ensuring even wear; whereas, vinyl has a pattern superimposed on it and shows quicker wear.
Linoleum is a medley of linseed oil (from flax plants), pine rosin, wood flour, cork flour, limestone and pigments, which form into granules and are compressed onto a jute backing. Evidence-based comparisons of LCA of flooring types including linoleum, vinyl, wool carpets and synthetic carpets have shown linoleum to be the most environmentally compatible floor covering. The "green" model would employ linoleum for clinical areas.

**Source:**

Environmental LCA of four types of linoleum, vinyl, wool carpets and synthetic carpets. Utrecht University's Department of Science, Technology and Society. The Netherlands, 1993.

3. **Type of paint**

VOCs are a major category of pollutants which exert a significant adverse affect on our breathable air. Their toxic and carcinogenic human health effects are also well documented (Elbir et al, 2006).

In our survey, all five dental offices were using conventional VOC latex paints. Recently, low VOC or no VOC paints have become available commercially. The Eco Spec paint formula (Benjamin Moore) contains ultra-low quantities of solvents which release volatile organic compounds (VOCs) into the air. The "green" model would employ this type of paint.
Note: This paint is the only major source of latex in the "green" model. All other dental materials would be carefully chosen to avoid the use of latex. In many cases, latex allergy develops after multiple exposures to latex. Interestingly, direct physical contact with latex-containing products is not necessary to initiate the allergic reaction. Simply breathing latex proteins in the air can lead to sensitivity and possibly full-blown allergy (RCDSO, Practice Advisory, April 2002).

**Waste Management:**

1. **Is paper from autoclave bags recycled?**

In our survey, four offices did not recycle the paper from autoclave bags. Soon after the survey, one office began to recycle the autoclave bags immediately. Again, using the Blue Bin program, the "green" model would recycle the paper half of the autoclave bags.

2. **Is paper recycled?**

Four out of the five offices surveyed recycled paper. The "green" model would recycle all paper used including shredded paper.

**3. Is recycled paper used?**

Two out of the five offices surveyed used recycled paper. The "green" model would only use 100% recycled paper.

While it is part of the accepted social meaning that recycling is a worthy endeavour, it may be helpful to examine some tangible data.

Why recycle?

- Each ton (2000 pounds) of recycled paper can save 17 trees, 380 gallons of oil, three cubic yards of landfill space, 4000 kilowatts of energy, and 7000 gallons of water. This represents a 64% energy savings, a 58% water savings, and 60 pounds less of air pollution.
- The 17 trees saved (above) can absorb a total of 250 pounds of carbon dioxide from the air each year. Burning that same ton of paper would create 1500 pounds of carbon dioxide.

**By recycling 1 ton of paper you save:**

- 17 trees
- 6953 gallons of water
- 463 gallons of oil
- 587 pounds of air pollution
- 3.06 cubic yards of landfill space
- 4077 Kilowatt hours of energy

**Source:** Weyerhaeuser Info

4100 kilowatts saved per ton recycled 60 lbs. of air pollution reduced per ton recycled. (**Source:** National Polymers Inc.)

In 1996, 42.3 million tons of papers were recycled in America. (**Source:** "Recycling and Buy Recycled Fact Sheets" America Recycles Day)

The overall paper and paperboard recovery rate was 44.7 percent for 1996. The total weight of paper and paperboard recovered in 1996 was 42.3 million tons, or 295 pounds per American citizen. (**Source:** American Forest and Paper Association)

In 1996, the average American recycled 329 pounds of paper- a 9% increase over 1995. (**Source:** "Recycling and Buy Recycled Fact Sheets" America Recycles Day)

**4. Is plastic from autoclave bags recycled?**

None of the five offices surveyed recycled their plastic autoclave bags, however, as previously mentioned, upon hearing that this recycling was easily achieved using Blue Bins, plastic recycling was immediately implemented in one office. The "green" model would employ Blue Bin recycling for the plastic half of the autoclave bags.

**5. Are developer and fixer solutions recycled?**

From our survey, four out of the five offices do recycle their fixer and developer solutions. The importance of this has already been discussed above. The "green" model would employ

digital x-rays which do not require the use of developer and fixer solutions.

**6. Are biohazards managed by a biohazard company?**

Biohazards include materials capable of causing disease or suspected of carrying microbes which could include blood-soaked gauze, tissues and syringes, but not extracted teeth (Hiltz, 2006).

In our survey, four out of the five offices do employ the services of a qualified biohazard company for proper disposal of this routine dental waste product. The "green" model would employ the services of a biohazard company.

**7. How many garbage bags (10L) are filled/day?**

The intent of this question was to investigate if any positive correlation existed between offices that did recycle paper and plastics to the fewness of the garbage bags used. No correlation could be determined. This was due to the fact that data collection for this question was non-uniform as certain offices had their garbage managed not by staff but by a general cleaning staff.

**8. Is lead foil from x-rays recycled?**

From our survey, three out of the five offices did recycle the lead foil. Interestingly, one office gave the lead foils to a patient who did better than recycling; he reused the lead to make

bullets. Again, the "green" office would employ digital radiography which does not use lead foils.

9. **Are reusable sundries being employed?**

Unfortunately, this question arose after the surveys were completed, thus we have no data. However, another environmental alternative to traditional disposable sundries such as plastic suction tips and plastic irrigation syringes is that of reusable (autoclaveable) stainless steel suction tips (low and high volume, surgical and endodontic) as well as reusable (autoclaveable) glass irrigation syringes (See appendix). Source: http://www.qualityaspirators.com/qa.php3?page=products&prod_type=aspirators

Multifit Glass Syringe (BD), Sinclair Dental Catalogue 2006, p. 237.

10. **Are recycled or biodegradable sundries being employed?**

This question also arose after the surveys were completed. In routine private practice, numerous sundries are consumed that perhaps do not enter ones consciousness. For example, disposable cups (eg. Dixie), paper towel, toilet paper. "Green" alternatives such as bio-degradable disposable cups and chlorine-free, high post-consumer recycled content paper products are readily available (www.greenshift.ca) and would be used by the "green" model.

## Green Recommendations

- Implement an eco-friendly sterilization program which eliminates the need for disposable autoclave wraps and simultaneously eliminates the need for disposable patient bibs. See item #2 under Consumption for details.
- Use reusable O.R. cotton towels instead of disposable patient bibs.
- Use an Energy Star washer and dryer, where applicable.
- Use fluorescent instead of halogen lighting, where practical.
- Use LCD instead of CRT computer screens.
- Use a dry instead of a wet dental vacuum pump.
- Use the Blue Bin recycling program to recycle separately the paper and plastic halves of one autoclave bag.
- Use digital radiography instead of traditional film-based x-rays.
- If using traditional x-rays, recycle fixer and developer solutions and recycle lead foil from x-rays.
- Consider using less harmful surface disinfectants in dental offices such as tea tree oil and thyme.
- Use linoleum as it is the environmental choice for flooring.
- Use an ultra-low VOC paint.
- Use reusable and bio-degradable sundries wherever possible (see Appendix)
    - Reusable cotton towels vs Disposable plastic/paper bibs
    - Reusable stainless steel high and low volume, surgical/endodontic suction tips vs Disposable plastic
    - Reusable glass irrigation syringe vs Disposable plastic
    - Bio-degradable disposable cups vs land fill burdening cups (e.g. Dixie)
    - Chlorine-free, high post-consumer recycled paper towels, towel paper vs traditional paper products

- Use an environmentally-friendly landscape company who will use natural growth product and procedures as an alternative to harmful pesticides.
- Use stainless steel (Hu-Friedy) prophy cups instead of the disposable prophy-containing cups. This means purchasing prophy paste in tubes (Zircate) or tubs. This also allows one to use only the amount of paste that is needed versus a predetermined amount which is often too much and wasteful/costly.
- Using disposable, plastic/paper barriers only as truly needed. Each office is encouraged to do a one-day consumption analysis exclusively for barriers and then calculate a week, month, year and career.

## Conclusion

Eco-friendly dentistry is not merely a 'feel good' endeavour. There is over-whelming evidence of global climate changes and the finite capacity of our planet's eco-system to absorb further depletion and degradation (Keller, 2007). If environmental degradation was a stock, the industrial nations would be the primary share-holders. Thus, it is an ethical duty for the western world to play a primary role in developing sustainable solutions.

Healthcare Environet (2007) states:

> "It is incompatible with the mission of the institutions devoted to healing to be significant consumers of resources and sources of environmental harm through air and wastewater emissions, hazardous and solid waste generation, greenhouse gas emissions and toxic chemical usage. Thus, reducing health care's

environmental impact has both a symbolic and practical significance."

Despite the numerically small but influentially significant isolated popular media reports which have and may continue to contradict volumes of solid evidence supporting global warming, it is incumbent on a profession that prides itself on evidence-based practices to reflect and act on the most current evidence. It is up to the conscious of each member of the dental community to implement practical eco-friendly changes to old, unsustainable consumption patterns.

## Appendix

- Please ask for pictures of many eco-friendly dentistry alternatives.


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