

THE HEALTH IMPLICATIONS OF REUSING SEWAGE

Dr. Nandini Sharma
Director Professor
Department of Community Medicine
Maulana Azad Medical College



Wastewater

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- Also written as **waste water**, is any water that has been adversely affected in quality by anthropogenic (an effect or object resulting from human activity) influence.
- **Municipal wastewater** is usually treated in a combined sewer, sanitary sewer, effluent sewer or septic tank.

- Sewage is the part of wastewater that is contaminated with feces or urine, but is often used to mean any wastewater. When this is done sewage refers to wastewater from sources including domestic, municipal, or industrial liquid waste products disposed of, usually via a pipe or sewer system.
- Untreated sewage may contain water; nutrients (nitrogen and phosphorus); solids (including organic matter); pathogens (including bacteria, viruses and protozoa); helminthes (intestinal worms and worm-like parasites) ; oils and greases; runoff from streets, parking lots and roofs; heavy metals (including mercury, cadmium, lead, chromium, copper) and many toxic chemicals including PCBs, PAHs, dioxins, furans, pesticides, phenols and chlorinated organics.

Wastewater reclamation– The need

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- UNPF 1999 estimated that by 2050 ----
 - 80% of the world's population i.e. **7.3-10.7 billion** will be living in developing countries of whom 55% will be in cities.
 - Freshwater scarcity and increased wastewater production therefore will further increase reliance on wastewater reuse particularly in developing nations.

Uses for Recycled Water

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- ❑ agriculture
- ❑ landscape
- ❑ public parks
- ❑ golf course irrigation
- ❑ cooling water for power plants and oil refineries
- ❑ processing water for mills, plants
- ❑ toilet flushing
- ❑ dust control,
- ❑ construction activities
- ❑ concrete mixing
- ❑ artificial lakes

Infectious Agents Potentially Present in Raw Domestic Wastewater

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AGENT	DISEASE
BACTERIA	
E.Coli	Gastroenteritis
S.Typhi	Typhoid fever
VIRUSES	
Polio virus	Polio, Gastroenteritis
Rota Virus	Acute Gastroenteritis
PROTOZOA	
E. Histolytica	Amoebiasis
Giardia	Giardiasis
PARASITES	
Ascaris	Ascariasis
Taenia	Taeniasis

Exposure To Reused Wastewater

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- Around **90%** of wastewater produced globally remains **untreated**, causing widespread water pollution, especially in low-income countries

- **Drinking water :**
 - ***Groundwater contamination*** occurs with wastewater use
 - ***Water bodies may be affected with untreated sewage discharged into it***

Most common water borne diseases

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- ❑ **Water-related vector-borne diseases**

(malaria, filariasis, Japanese encephalitis-**all linked to irrigation development to a greater or lesser extent**, depending on the location)

- ❑ **Water based diseases**

(schistosomiasis, guinea worm infection)

- ❑ **Water-borne and water washed infections**

(mainly of the **gastro-intestinal type** linked to irrigation schemes and wetland areas where **communities lack access to safe drinking water and adequate sanitation**)

Health hazards of waste water reuse --- recreational water

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- ❑ Waste water may be used to establish lakes and ponds
- ❑ Direct contact in swimmers may lead to outbreaks of Gastroenteritis, Diarrhoea, Cryptosporidiosis etc

Exposure to reused wastewater

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□ AGRICULTURE

- Increasingly, is using untreated wastewater for irrigation. Cities provide lucrative markets for fresh produce, so are attractive to farmers.
- Agriculture has to compete for increasingly water resources with industry and municipal users, there is often no alternative for farmers but to use water polluted with urban waste directly to water their crops.

Health hazards of polluted irrigation water

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- ❑ Wastewater from cities can contain a mixture of chemical and biological pollutants.
- ❑ In low-income countries, there are often high levels of pathogens from excreta

Health hazards of irrigation using wastewater

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- ❑ The health impact of **utilization of raw domestic sewage for vegetable cultivation** in the suburbs of Asmara, Eritrea, was assessed.
- ❑ Results showed
 - **heavy contamination of vegetables by fecal coliforms and Giardia cysts as well as Shigella and Salmonella**
 - **Stool samples from 75 occupationally exposed farmers revealed that 45% of them were harboring Giardia cysts**
 - **Dietary intake of raw greens (lettuce, cabbage) grown on the raw sewage appears to cause Giardiasis, diarrhoea and amebiasis in the farming community.**

Agriculture direct use: effects

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- ❑ Waste Water or natural water supplies into which wastewater has been discharged, are likely to contain pathogenic organisms similar to those in the original human excreta
- ❑ Disease prevention programmes have centred upon four groups of pathogens potentially present in such wastes: bacteria, viruses, protozoa and helminths

Pathogenic organisms *bacteria*

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- ❑ The faeces of a healthy person contains large numbers of bacteria ($> 10^{10}/g$), most of which are not pathogenic
- ❑ Diarrhoea is the most prevalent type of infection, with cholera the worst form
- ❑ Typhoid, paratyphoid and other *Salmonella* type diseases are also caused by bacterial pathogens.

Pathogenic organisms

Viruses

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- Load in the faeces ($> 10^9$ /g)

- Five groups of pathogenic excreted viruses are particularly important:
 - adenoviruses
 - enteroviruses (including polioviruses)
 - hepatitis A virus
 - reoviruses
 - diarrhoea-causing viruses (especially rotavirus)

Pathogenic organisms

Protozoa

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- ❑ **Cause diarrhoea and dysentery**
- ❑ Infective forms of these protozoa are often passed as cysts in the faeces and humans are infected when they ingest them
- ❑ **Only three species** are considered to be **pathogenic:**
 - *Giardia lamblia*,
 - *Balantidium coli* and
 - *Entamoeba histolytica*.
- ❑ **An asymptomatic carrier state is common**

Pathogenic organisms

Helminths or Worms

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- ❑ The species that pass eggs or larval forms in the excreta are of importance in considering wastewater use
- ❑ Two groups:
 - Roundworms (nematodes)
 - Flat worms in cross section:
 - tapeworms which form chains of helminths "segments"
 - flukes which have a single, flat, unsegmented body.

Risk Associated

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- ❑ Pathogen excreted in water
- ❑ Freshwater + Pathogen = Sewage
- ❑ Maybe treated or directly applied for crop production or discharged in a watercourse and indirect use occurs further downstream

Pathogen survival in Field : Persistence

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- ❑ Almost all excreted pathogens can survive in soil... for a sufficient length of time to pose potential risks to farm workers(WHO)
- ❑ Pathogens survive on crop surfaces for a shorter time than in the soil
- ❑ Survival times are longer than crop growing cycles in vegetables and pose risk to crop handlers and consumers.

Relative health risk from wastewater use

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- **High: Helminths** (the intestinal nematodes - *Ascaris*, *Trichuris*, hookworm and *Taenia*)
- **Lower: Bacterial infections** (i.e. cholera, typhoid and shigellosis) and **Protozoan infections** (i.e. amebiasis, giardiasis)
- **Least: Viral infections** (viral gastroenteritis and infectious hepatitis)

Low(est) risk to consumer but field worker protection still needed

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- ***Crops not for human consumption*** (for example cotton, sisal)
- ***Crops normally processed by heat or drying before human consumption*** (grains, oilseeds, sugar beet)
- ***Vegetables and fruit grown exclusively for canning or other processing that effectively destroys pathogens***

Low(est) risk to consumer but field worker protection still needed (contd...)

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- ❑ ***Fodder crops and other animal feed crops that are sun-dried and harvested*** before consumption by animals
- ❑ ***Landscape irrigation in fenced areas without public access*** (nurseries, forests, green belts)

Increased risk to consumer and handler

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- ***Pasture, green fodder crops***
- ***Crops for human consumption that do not come into direct contact with wastewater***, on condition that none must be picked off the ground and that spray irrigation must not be used (tree crops, vineyards, etc.)
- ***Crops for human consumption normally eaten only after cooking*** (potatoes, eggplant, beetroot)

Increased Risk to Consumer and Handler(contd....)

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- ***Crops for human consumption, the peel of which is not eaten*** (melons, citrus fruits, bananas, nuts, groundnuts)

- ***Any crop not identified as high-risk if sprinkler irrigation is used***

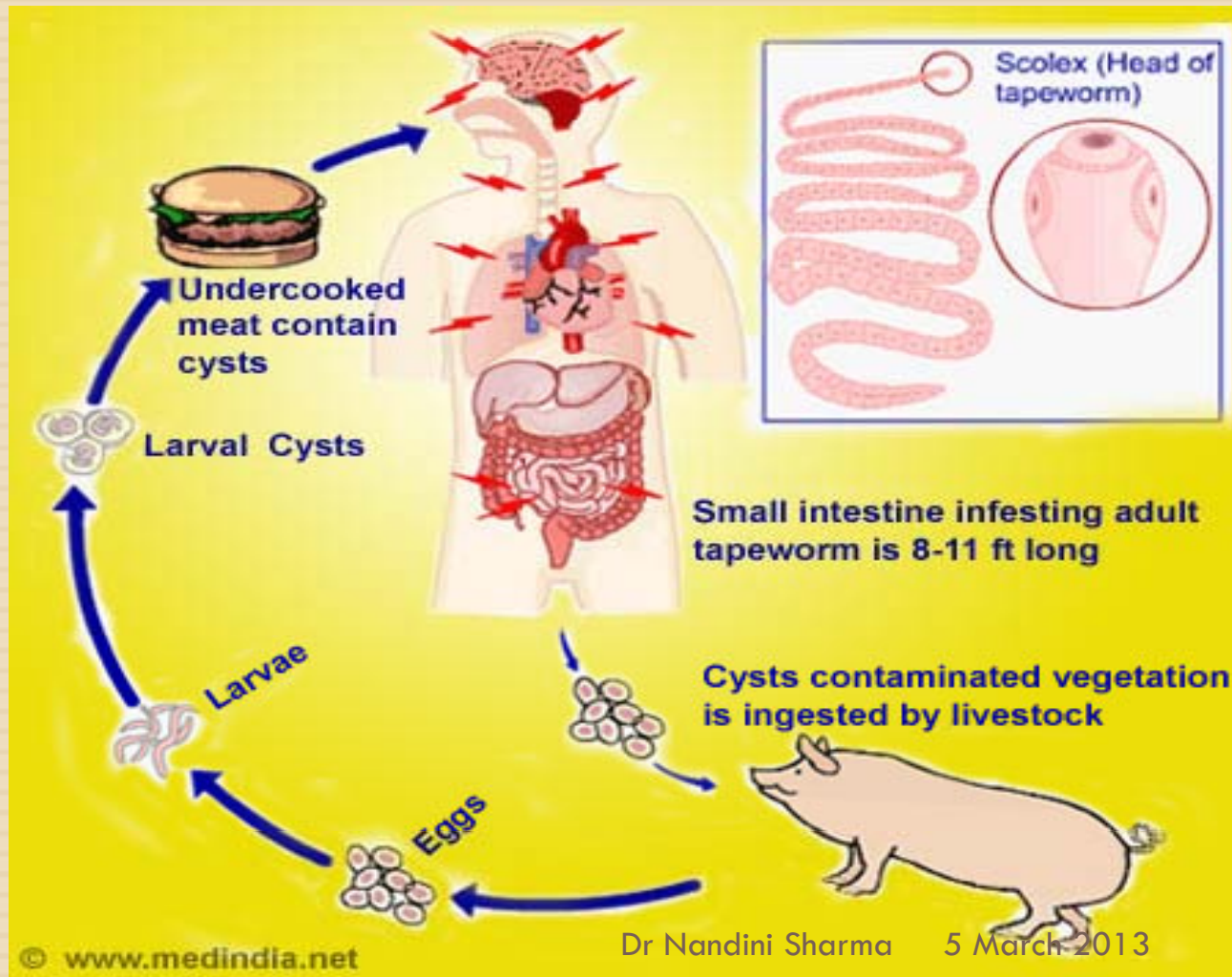
Highest risk to consumer, field worker and handler

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- ***Any crops eaten uncooked and grown in close contact with wastewater effluent*** (fresh vegetables such as lettuce or carrots, or spray-irrigated fruit)
- ***Landscape irrigation with public access*** (parks, lawns, golf courses)

Cysticercosis: Also a vegetarians disease

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Human cysticercosis and Indian scenario: a review

KASHI NATH PRASAD*, AMIT PRASAD, AVANTIKA VERMA and ALOUKICK KUMAR SINGH

Department of Microbiology, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow 226 014, India

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- 26.3% to 53.8% active epilepsy cases in the developing world including India and Latin America are due to NCC
- Cysticercosis has been designated as a “biological marker” of the social and economic development of a community

EPIDEMIOLOGY OF *TAENIA SOLIUM* TAENIASIS/*CYSTICERCOSIS* IN INDIA AND NEPAL

Vedantam Rajshekhar

Department of Neurological Sciences, Christian Medical College Hospital, Vellore, India

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- Less than 1-2% of Indian patients with NCC admit to eating pork. More than 95% are vegetarians
- Human cysticercosis is more prevalent in northern states of India than the southern states
- Consumption of raw vegetables, as salads, is less prevalent in South India
- Salads are eaten with every meal in the North. This could be the source of infection

Agriculture Indirect Use: Effect

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- ❑ Indirect use occurs when treated, partially treated or untreated wastewater is discharged to reservoirs, rivers and canals that supply irrigation water to agriculture
- ❑ Poses the same health risks as planned wastewater use projects, but may have a greater potential for health problems because the water user is unaware of the wastewater being present.

Indirect Effect (contd...)

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- ❑ In emerging nations, industrial development is outpacing environmental regulation, there are increasing risks from inorganic and organic chemicals
- ❑ The WHO in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environmental Program (UNEP), has developed guidelines for safe use of wastewater

WHO Guidelines for controlling the quality of water used to irrigate vegetable or other high-risk crops

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- should be a performance goal to achieve for those water supplies which presently exceed this level

- Using these as irrigation standards would help to:
 - assess the extent of contamination;

 - reduce the disease infection risk until suitable wastewater treatment works are in place;

 - improve the basic health level in the rural areas

Helminth Egg vs. Faecal coliform as Monitoring guideline

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- Shuval *et al.* stressed that a major or total reduction in negative health effects could be made if the greatest emphasis is placed on helminth egg removal during wastewater treatment
- *little or no experience is available* in using helminth egg concentration in irrigation water monitoring *nor are there well understood monitoring techniques available*
- The initial emphasis by WHO therefore is to **focus on the faecal coliform** guideline as **monitoring and evaluation techniques for these are well understood**

Standards in use

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- The US Environmental Protection Agency (EPA), together with the National Academy of Sciences (NAS): **acceptable guideline for irrigation with natural surface water, including river water containing wastewater discharges, be set at 1 000 faecal coliforms per 100 ml (US EPA, 1973)**
- The US EPA level is also consistent with the 1 000-2000 faecal coliforms per 100 ml level used as a standard for bathing in Europe (WHO, 1989)

WHO guidelines (contd...)

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- The guidelines in the following table are for the microbiological quality of treated effluent from a wastewater treatment plant when that water is intended for crop irrigation
- The WHO Scientific Group on Health Guidelines intended these as design goals in planning wastewater treatment plants and they were not intended as standards for quality surveillance or routine monitoring of irrigation water

Recommended microbiological quality guidelines for wastewater use in agriculture

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Category	Reuse condition	Exposed group	Intestinal nematodes ^b (arithmetic mean no. of eggs per litre ^c)	Faecal coliforms (geometric mean no. per 100 ml ^c)	Wastewater treatment expected to achieve the required microbiological quality
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks ^d	Workers, consumers, public	≤ 1	$\leq 1000^d$	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees ^e	Workers	≤ 1	No standard recommended	Retention in stabilization ponds for 8-10 days or equivalent helminth and faecal coliform removal
C	Localized irrigation of crops in cat. B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment as required by the irrigation technology, but not less than primary sedimentation

Dr Nandini Sharma 5 March 2013

The 2006 WHO guidelines

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- represent a radical departure from the 1989 guidelines,
- much more soundly based on the protection of human health.
- acceptance of the tolerable additional burden of disease used in the 2004 WHO drinking water quality guidelines of $\leq 10^{-6}$ DALY loss per person per year that translates to a tolerable rotavirus infection risk of 10^{-3} pppy.

The 2006 WHO guidelines(contd..)

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- use of quantitative microbial risk analyses based on likely human exposure scenarios results in robust estimates of the risks to human health from, and the corresponding pathogen reductions required for, both restricted and unrestricted irrigation
- National governments have to decide whether this baseline value of 10^{-6} DALY loss pppy is appropriate or whether to adopt, at least initially, a higher value (10^{-5} or even 10^{-4} DALY loss pppy)
- can be confidently used without the general need in all cases to undertake case-specific estimates of the risks to human health resulting from the use of wastewater

Reduction of Health Risks : Multiple Barrier Approach

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- ❑ The International Water Management Institute (worked in India, Pakistan, Vietnam, Ghana, Ethiopia, Mexico)
- ❑ Farmers encouraged to adopt various risk-reducing behaviours:
 - ceasing irrigation a few days before harvesting to allow pathogens to die off in the sunlight
 - applying water carefully so it does not contaminate leaves likely to be eaten raw
 - Cleaning vegetables with disinfectant
 - Allowing fecal sludge used in farming to dry before being used as a human manure

Prevention of health hazards

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- ❑ **Protection of water sources (Difficult to protect surface water)**
- ❑ **Purification of water**
- ❑ **Hand washing**

Hand-washing (40-60 seconds)

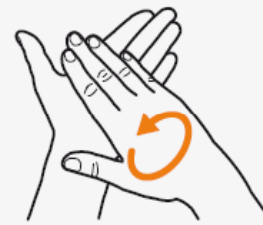
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1. Wet hands with water & Apply enough soap to cover all hand surfaces;

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2. Rub hands palm to palm;

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3. Right palm over left dorsum with interlaced fingers and vice versa;

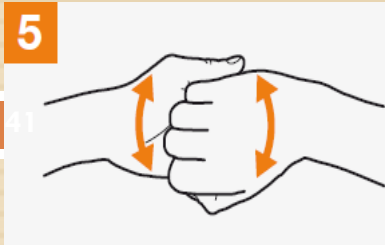
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4. Palm to palm with fingers interlaced;

Hand-washingContd

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5. Backs of fingers to opposing palms with fingers interlocked;

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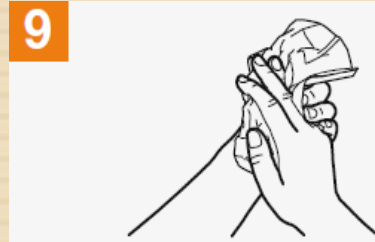
8. Rinse hands with water;

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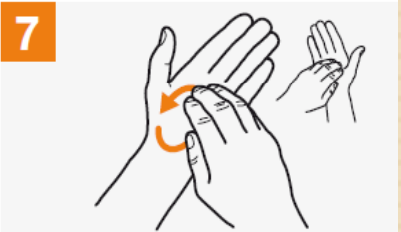
6. Rotational rubbing of left thumb clasped in right palm and vice versa;

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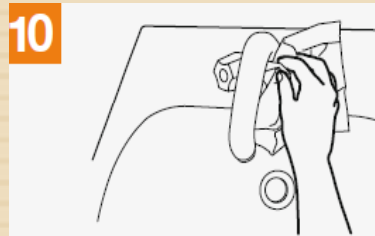
9. Dry hands thoroughly with a single use towel;

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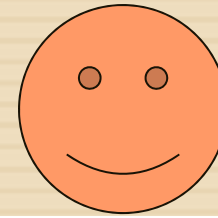
7. Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa;

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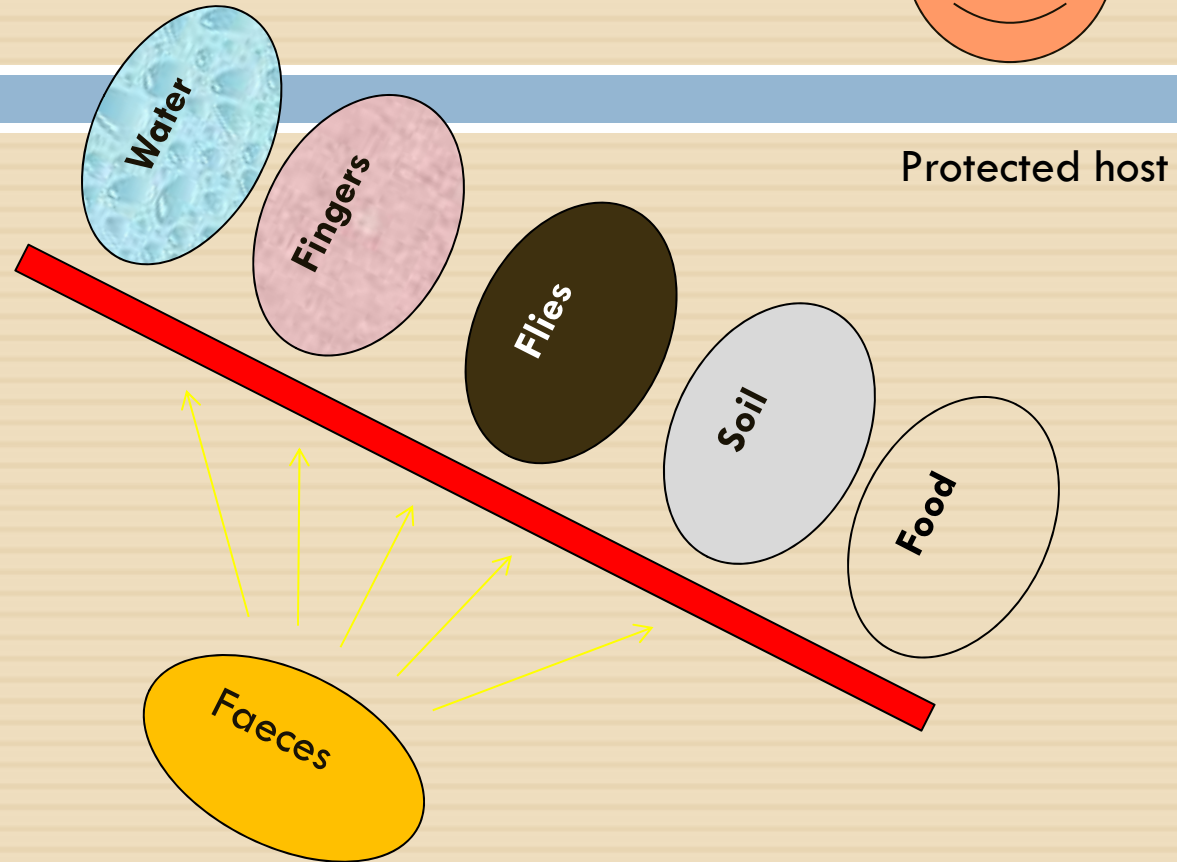


10. Use towel to turn off faucet.

Sanitation barrier



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Prevention of infection transmitted through vegetables

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- ❑ Avoid eating raw salads when not sure of hygiene levels
- ❑ Wash thoroughly all vegetables which are to be eaten raw as well those that are lightly stir fried
- ❑ Soaking in potassium permanganate is helpful. But only very dilute solution should be used
- ❑ Good personal and food hygiene should be maintained
- ❑ Raw meat and fish e.g. must not be allowed to come in contact with cooked
- ❑ Vegetables and fruits even the ones peeled should be washed
- ❑ Kitchen counters must be kept clean

