

Costs of Fluoride Removal Technologies in Ethiopia

Lars Osterwalder, 6th February 2013

Introduction

“Optimization and Acceptance of Fluoride Removal Options for Drinking Water in Rural Ethiopia”

Timeframe: May 2009 – June 2012

Location: Ethiopia, Oromia Region

Partners: Eawag, Addis Ababa University, Oromo Self-Help
Organization, National Fluorosis Mitigation Project Office

Funding: SNF-SDC

Introduction – Fluoride Removal Technologies



Introduction - Research Questions

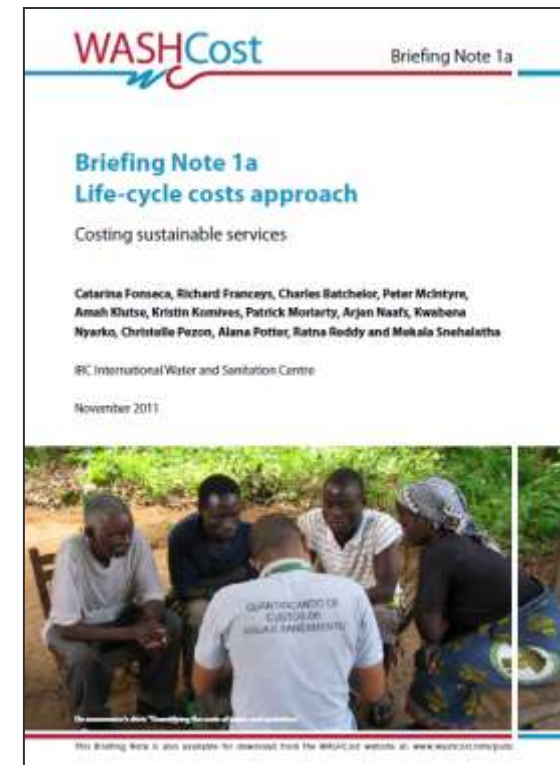
- How much does fluoride-free water cost in Ethiopia?
- How high is the willingness to pay of end consumer?



Methodology – Cost Estimation

Cost Categories

- Capital expenditure (CapEx)
- Capital maintenance expenditure (CapManEx)
- Operation & minor maintenance expenditure (OpEx)
- Expenditure on direct support (ExpDS)
- Expenditure on indirect support (not considered)
- Costs of capital (not considered)



www.washcost.info/pubs

Exchange rate: 18 ETB/USD

Capital Expenditures (CapEx)

USD/m³

$$= \frac{\text{Initial Hardware and Software Expenditures [USD]}}{\text{Lifespan [y]} \times \text{Volume of Water Treated [m}^3\text{/y]}}$$

Initial Expenditures:	Based on field data and estimations
Lifespan:	Assumed to be 10 years for all technologies
Volume of treated water:	Variable

Capital Expenditures (CapEx)



Filters: Raw and treated water storage tank (5,000 L), two filter tanks (2,000 L), plastic tanks



Nalgonda: Raw and treated water storage tank (5,000 L), two reactors (4,000 L), electrical stirrer



Electro Coagulation: Raw and treated water storage tank (5,000 L), two concrete treatment basins (600 L), housing



Reverse Osmosis: European product, including importation and installation

Capital Expenditures (CapEx)

USD/m³

Technology	<u>Case I</u> 5 mg/L F <i>5,000 lpd</i>	<u>Case III</u> 10 mg/L <i>2,500 lpd</i>
Activated Alumina	0.30	0.60
Aluminum Hydroxide	0.30	0.60
Bone Char	0.30	0.60
Nakuru Technique	0.30	0.60
Electro Coagulation	0.50	1.10
Nalgonda Technique	0.60	1.30
Reverse Osmosis	2.20	4.30

Capital Maintenance Expenditures (CapManEx)

USD/m³

Occasional costs of renewing (replacing, rehabilitating, refurbishing, restoring) assets in order to ensure that services continue at the same level of performance that was first delivered.

- Replacement of filter material
- Replacement of aluminum electrodes
- Replacement of membrane and pre-filters
- Delivery of chemicals (in bulk) to a community

Capital Maintenance Expenditures (CapManEx)



Filters: Costs of fresh filter material and regenerated material, average fluoride uptake capacity (independent of fluoride concentration and general composition of raw water)



Nalgonda: Costs and dosage of alum and lime



Electro Coagulation: Cost of aluminum electrode and costs and dosage of hydrochloric acid



Reverse Osmosis: Costs and lifespan of membrane, pre-filter and other spare parts

Capital Maintenance Expenditures (CapManEx)

USD/m³

Technology	<u>Case I</u> <i>5 mg/L F</i> 5,000 lpd	<u>Case III</u> <i>10 mg/L</i> 2,500 lpd
Activated Alumina	1.10	2.20
Aluminum Hydroxide	1.20	2.40
Bone Char	1.10	2.20
Nakuru Technique	0.90	2.10
Electro Coagulation	0.20	0.40
Nalgonda Technique	0.50	0.90
Reverse Osmosis	1.10	2.20

Operation & Minor Maintenance Expenditure (OpEx)

Costs for daily operation and small maintenance, handled directly by the WASH committee.

- Fuel for generator
- Salary for operator/caretaker
- Raw water (incl. minor maintenance)

Operation & Minor Maintenance Expenditure (OpEx)



Filters: Raw water



Nalgonda: Raw water, operator and electricity



Electro Coagulation: Raw water, operator and electricity



Reverse Osmosis: Raw water, operator and electricity

Operation & Minor Maintenance Expenditure (OpEx)

USD/m³

Technology	<u>Case I</u> 5 mg/L F 5,000 lpd	<u>Case III</u> 10 mg/L 2,500 lpd
Activated Alumina	0.30	0.30
Aluminum Hydroxide	0.30	0.30
Bone Char	0.30	0.30
Nakuru Technique	0.30	0.30
Electro Coagulation	1.30	1.30
Nalgonda Technique	0.70	0.70
Reverse Osmosis	1.40	1.40

Expenditure on Direct Support (ExDS)

Pre- and post-construction support activities directed to local level stakeholders and users

Assumption

A NGO, a private company or the woreda water office is supervising, supporting and monitoring the implementation and subsequent maintenance of fluoride removal units

Expenditure on Direct Support (ExDS)

Expenditures that have to be covered:

- Trainings for community
- Community surveys
- Promotion activities
- Monitoring and documentation
- Staff salaries
- Transportation
- Office, computer, stationery
- ...

Budget: 1 Mio ETB/year for 100 community units (560 USD/unit)

Assumption: Average water production is 4,000 L/day/unit

Expenditure on Direct Support (ExDS)

USD/m³

Technology	<u>Case I</u> 5 mg/L F 5,000 lpd	<u>Case III</u> 10 mg/L 2,500 lpd
Activated Alumina	0.40	0.40
Aluminum Hydroxide	0.40	0.40
Bone Char	0.40	0.40
Nakuru Technique	0.40	0.40
Electro Coagulation	0.40	0.40
Nalgonda Technique	0.40	0.40
Reverse Osmosis	0.40	0.40

Estimated Total Expenditures

USD/m³

Technology	<u>Case I</u> 5 mg/L F 5,000 lpd	<u>Case III</u> 10 mg/L 2,500 lpd
Activated Alumina	2.00	3.40
Aluminum Hydroxide	2.20	3.70
Bone Char	2.10	3.50
Nakuru Technique	1.90	3.30
Electro Coagulation	2.50	3.20
Nalgonda Technique	2.10	3.20
Reverse Osmosis	5.10	8.40

Addis Ababa: 0.10 – 0.65 USD/m³

Berlin: 2.60 USD/m³

Methodology – Willingness to Pay

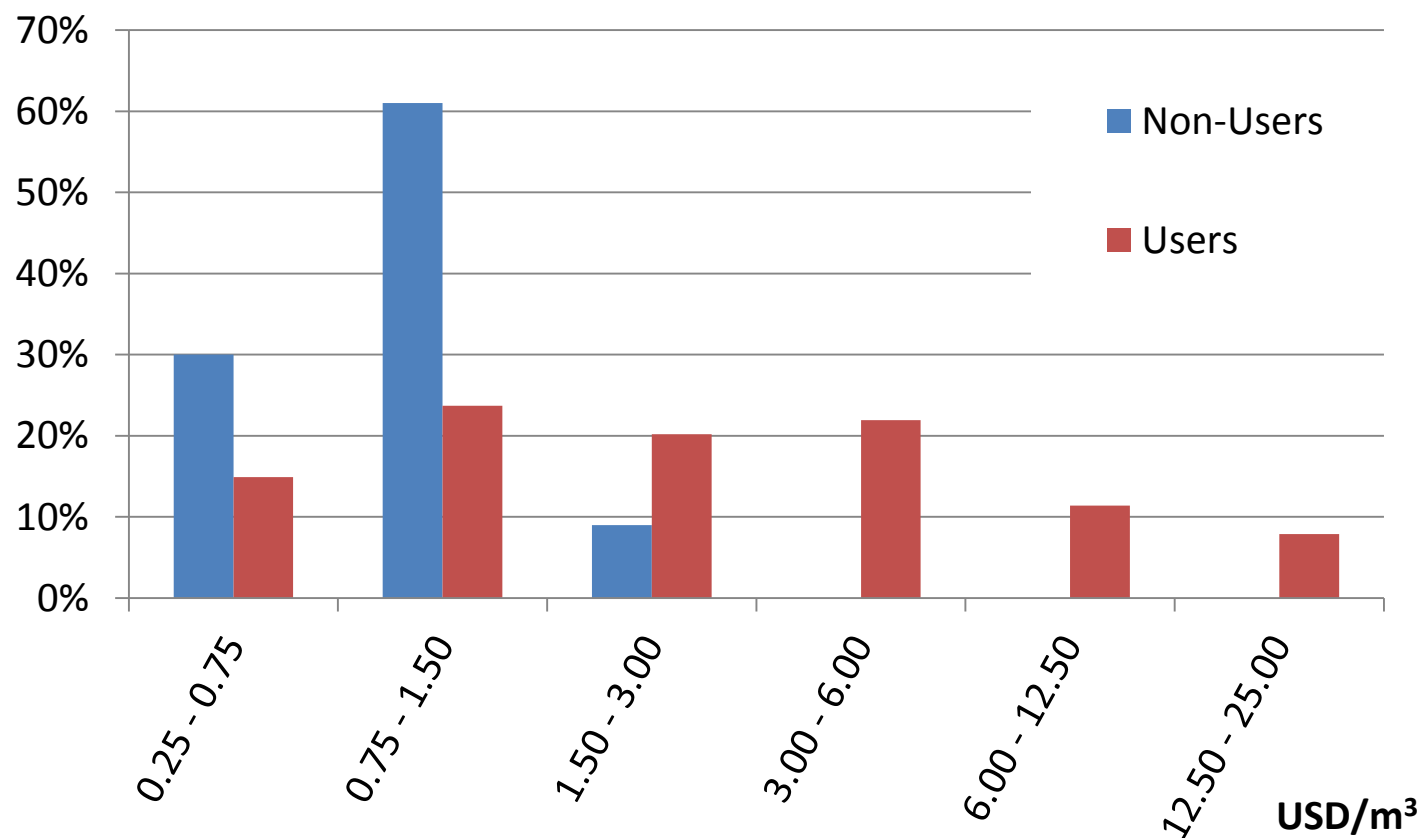
Structured Questionnaire

- Household Filter Users (N = 115, Dec 2009, Wayo Gabriel & Chalalaka)
- Non-Users (N = 100, Mar 2010, Wayo Gabriel)

“How much are you willing to pay for one jerrycan of fluoride free water?”

Willingness to Pay

*How much would you be willing to pay for one jerrycan of fluoride free water from the community filter?**



* Results converted from ETB/jerrycan to USD/m³

Willingness to Pay

Average willingness to pay:

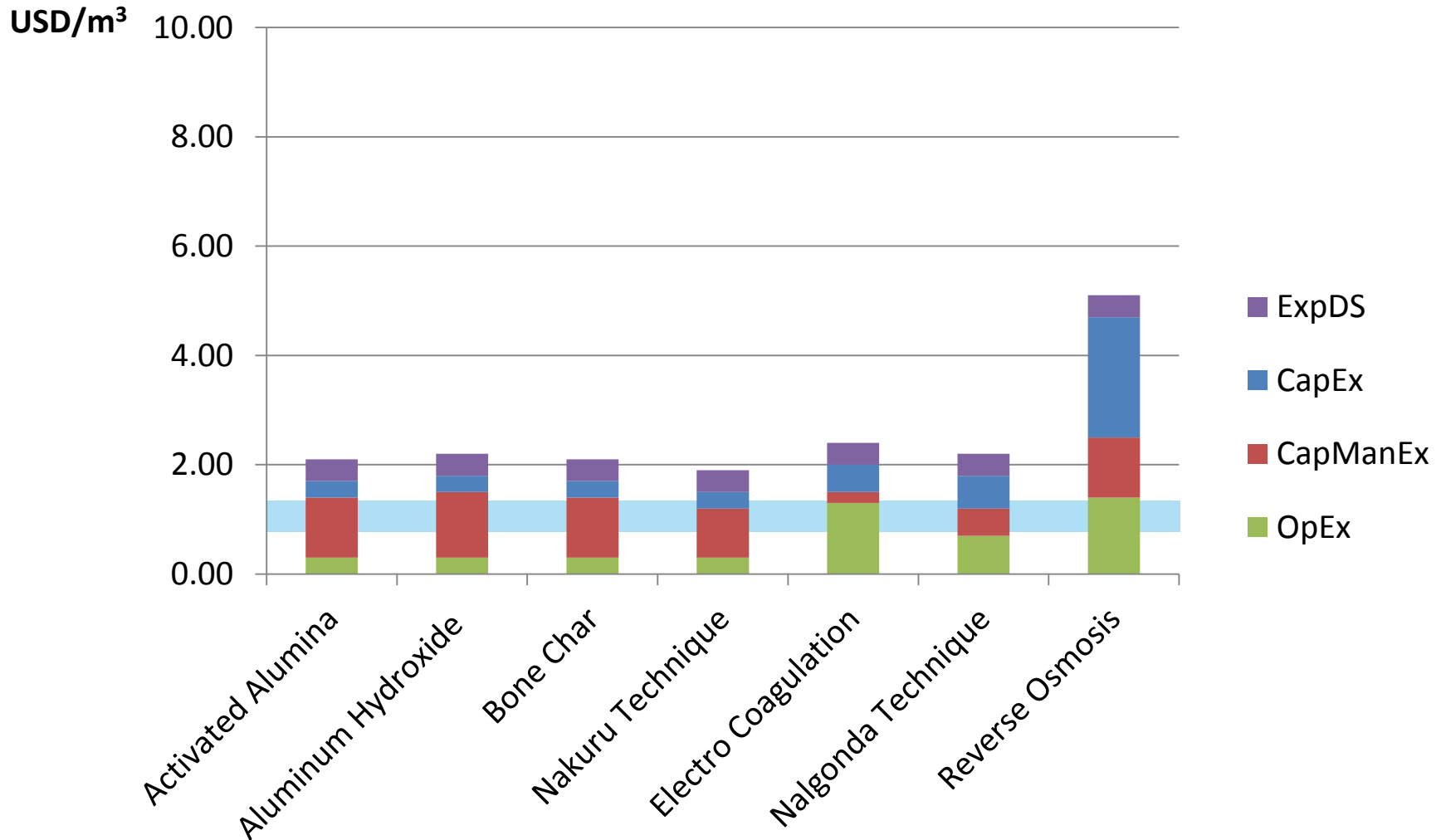
- Non-Users: 1.15 USD/m³
- Users: 4.30 USD/m³

Amount that 75% of the population are willing to pay:

- Non-Users: 0.70 USD/m³
- Users: 1.40 USD/m³ (= 0.50 ETB/jerrycan)

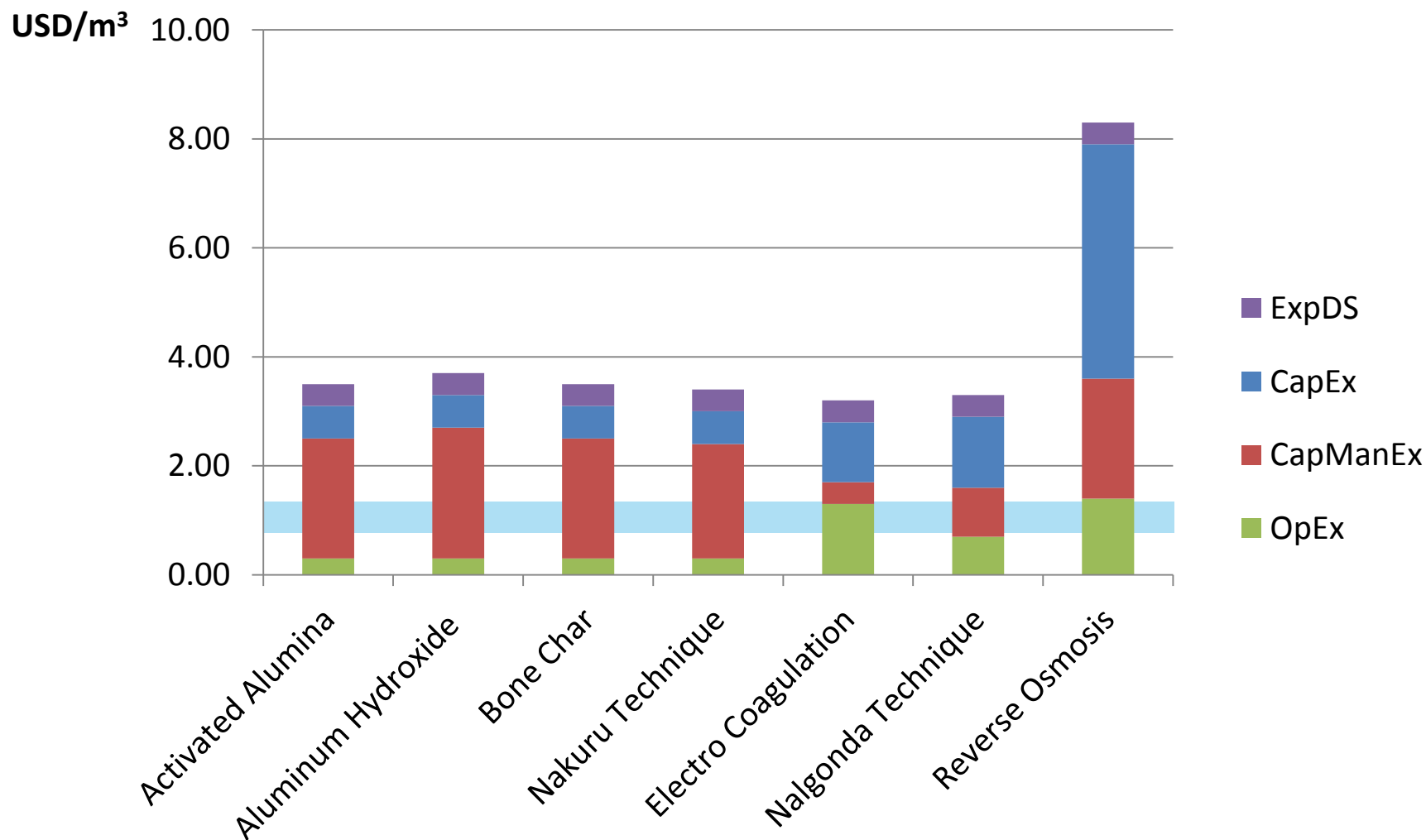
Results

Fluoride concentration: 5 mg/L, average daily consumption: 5,000 L/day



Results

Fluoride concentration: 10 mg/L, average daily consumption: 2,500 L/day



Conclusions

- Rural communities in Ethiopia are not willing to (or cannot) afford to cover the full costs of fluoride removal technologies
- Rural communities may be able to cover operation & minor operation expenditures and capital maintenance expenditures (in case of high water consumption and low fluoride concentrations)
- Behavior change interventions (promotion) may increase the willingness to pay

Recommendations

- Explore potential and costs of alternative water sources (well-sharing, piped water, rain water harvesting)
- Explore sustainable financing mechanisms and distribution channels
- Agreement on who is supposed to cover what costs
- Monitoring of costs
 - Further data collection about performance and costs of the different technologies introduced in Ethiopia
- Consider holistic water quality - and not just fluoride

Thank you!

Lars Osterwalder

Desert Rose Consultancy, Addis Ababa

lars@drcethiopia.net

+251 (0)912 79 58 17