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Compulsory Ethiopian Standard

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Ambient Surface Water for Irrigation — Requirements

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Foreword

This Ethiopian Standard has been prepared under the direction of the Technical Committee for water quality (TC 78) and published by the Institute of Ethiopian Standards (IES).

Application of this standard is compulsory with respect to clauses of EC, TDS, SAR, Boron, Chloride, E.coli, As, Cd, Pb and Cr.

A Compulsory Ethiopian Standard shall have the same meaning, interpretation and application of a "Technical Regulation" as implied in the WTO – TBT Agreement.

Implementation of this standard shall be effective as of --------------------------------

In preparing this standard the following reference is used:

- Australian and New Zealand (2023). Guidelines for fresh & Marine Water quality for the protection of aquatic ecosystem.
- Australian and New Zealand (2000) Guidelines for Fresh and Marine Water Quality Volume 1 National water quality management strategy; no.4
- Canadian Environmental Quality Guidelines (1999). Canadian Council of Ministers of the Environment. Environment Canada
- South Africa Water Quality Guidelines (1996): South African Water Quality Guidelines - Agricultural Water Use: Irrigation, volume 4
- Food and Agriculture Organization (1985). Water quality for agriculture. Irrigation and Drainage.

Acknowledgement is made for the use of information from the above publications. MoWE and WLRC are acknowledged for preparing the draft standard document with financial and technical support.

Ambient Surface Water Quality for Irrigation — Requirements

1. Scope

This Ethiopian standard specifies the physical, chemical, and biological requirements of Ambient Surface Water for Irrigation Use.

2. Normative references

The following referenced documents referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies

- ES ISO 7888:2024. Water quality — Determination of electrical conductivity.
- ES ISO 9308-3:2015. Water quality — Detection and enumeration of *Escherichia coli* and coliform bacteria.
- ISO 10260:2007. Water quality — Measurement of biochemical parameters — Spectrometric determination of chlorophyll-a concentration.
- ES 609, Water quality - Determination of total solids.
- ES ISO 4833, Microbiology - General guidance for the enumeration of microorganisms - Colony count technique at 30o C.
- ES ISO 5666-3, Water quality - Determination of total mercury by flameless atomic absorption Spectrophotometry - part 3: Method after digestion with bromine.
- ES ISO 5961, Water quality - Determination of cadmium by atomic absorption spectrometry.
- ES ISO 6107, Water quality - Vocabulary.
- ES ISO 6332, Water quality - Determination of iron - Spectrometric method using 1,10 phenanthroline.

- ES ISO 6333, Water quality - Determination of manganese - Formaldoxime spectrometric method.
- ES ISO 6468, Water quality - Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes - Gas chromatographic method after liquid - liquid extraction.
- ES ISO 6595, Water quality - Determination of total arsenic - Silver diethyldithiocarbamate spectrophotometric method.
- ES ISO 7980, Water quality - Determination of calcium and magnesium - Atomic absorption spectrometric method.
- ES ISO 8288, Water quality - Determination of cobalt, nickel, copper, zinc, cadmium and lead - Flame atomic absorption spectrometric method.
- ES ISO 9280, Water quality - Determination of sulfate - Gravimetric method using barium chloride.
- ES ISO 9297, Water quality - Determination of chloride - Silver nitrate titration with chromate indicator (Mohr's method).
- ES ISO 9308-1, Water quality - Detection and enumeration of coliform organisms, thermotolerant coliform microorganisms, and presumptive Escherichia coli - Part 1: Membrane filtration method.
- ES ISO 9696, Water quality - Measurement of gross alpha activity in non-saline water - Thick source method.
- ES ISO 9697, Water quality - Measurement of gross beta activity in non-saline water.
- ES ISO 9964-1, Water quality - Determination of Sodium and Potassium - Part 1: Determination of Sodium by atomic absorption spectrometry.
- ES ISO 9965, Water quality - Determination of selenium – Atomic absorptions pectrometric method (hydride technique).
- ES ISO 10359-1, Water quality - Determination of fluoride - Part 1: Electrical probe method for potable and lightly polluted water.

- ES ISO 10523, Water quality - Determination of pH.
- ES ISO 11083, Water quality - Determination of chromium (VI) - Spectrometric method using 1,5-diphenyl-carbazide.
- ES ISO 12020, Water quality - Determination of aluminium - Atomic absorption spectrometric methods..

3. Terms and Definitions

For the purpose of this standard, the following definitions and terms defined in ES ISO 6107:2021(en), US EPA Terms & Acronyms and WHO shall apply.

3.1

Ambient Surface Water

The natural, untreated water found on the Earth's surface including rivers, lakes, streams, ponds, wetlands, and reservoirs.

3.2

Biological Requirments

Biological indicators used to determine water quality for irrigation.

3.3

Chemical Requirements

The set of chemical parameters and associated limit values established to ensure that the chemical composition of surface water is suitable for its designated uses.

3.4

Designated Uses

Specific beneficial purposes for irrigation requiring defined water quality criteria.

3.5

Heavy Metals

Metallic elements with high atomic weight and density that are toxic even at low concentrations and tend to accumulate in living organisms.

3.6

Irrigation Water

Water used for crop or landscape irrigation, subject to quality standards that prevent soil salinization, 3.9.

3.7

Permissible Limits

The maximum or minimum allowable concentration or range of a physical, chemical, or biological parameter in surface water that shall not be exceeded in order to protect designated water uses.

3.8

Physical Requirements

The specified limits or ranges for measurable physical properties of ambient surface water that must be met to ensure the water is suitable for its designated uses without causing adverse effects.

3.9

Water Quality Requirement

A set of defined parameters characterizing the quality of water to assess its suitability for specific uses.

4. Requirements

4.1.

Physical Requirements

Table 1: EC/TDS requirements of surface water for irrigation use.

EC/TDS range	TDS/EC tolerance	Corresponding crops	Test Method

	class		
EC < 0.7 dS/m; TDS < 500 mg/L	Not Tolerant	Strawberry, Bean, Carrot	APHA 2510 B; ISO 7888; APHA 2540 C
EC < 1.2 dS/m; TDS < 800 mg/L	Slightly Tolerant	Plum, Grape, Peach, Pear, Apple; Onion, Radish, Pea, Pumpkin, Lettuce, Pepper, Muskmelon, Sweet potato, Sweet corn, Potato, Celery, Cabbage, Cauliflower, Cowpea, Broadbean, Sunflower, Corn	
EC < 2.2 dS/m; TDS < 1,500 mg/L	Moderately Tolerant	Spinach, Cucumber, Tomato, Squash, Brussels sprout, Broccoli, Turnip; Alfalfa, Big trefoil, Beardless wildrye	
EC < 3.6 dS/m; TDS < 2,500 mg/L	Tolerant	Beet, Zucchini, Rape, Sorghum, Oat hay, Wheat hay, Sweet clover, Birdsfoot trefoil, Perennial ryegrass	
EC < 5.0 dS/m; TDS < 3,500 mg/L	Very Tolerant	Asparagus, Soybean, Safflower, Oats, Rye, Wheat, Sugar beet, Barley	

4.2.

Chemical Requirements

4.2.1.

General Chemical Indicators

Table 1: General chemical indicator requirements of surface water for irrigation use.

Parameter	Permisible Iimit	Test Method
pH	6.5–8.4	APHA 4500-H+ B
DO (mg/L)	≥ 3	ISO 5814/2013
Aluminum (Al^{3+}) (mg/L)	≤ 5	APHA 3500-Al B
Beryllium (mg/L)	≤ 0.1	APHA 3120 B; APHA 3125 B
Fluoride (F-) (mg/L)	≤2	APHA 4500-F-C

Table 3: Boron requirements of surface water for irrigation use.

Boron concentration (mg/L)	Boron tolerance class	Corresponding crops	Test Method
< 0.5	Very Sensitive	Lemon, Blackberry	APHA 4500-B B
0.5 – 0.75	Sensitive	Avocado, Grapefruit, Orange, Apricot, Peach, Cherry, Plum, Grape, Walnut, Pecan, Cowpea, Onion	
0.75 – 1.0	Sensitive	Garlic, Sweet potato, Wheat, Barley, Sunflower, Sesame, Strawberry, Groundnut/Peanut	
1.0 – 2.0	Moderately Sensitive	Pepper (red), Pea, Carrot, Radish, Potato, Cucumber	
2.0 – 4.0	Moderately Tolerant	Lettuce, Cabbage, Celery, Oats, Maize, Mustard, Sweet clover, Squash	
4.0 – 6.0	Tolerant	Sorghum, Tomato, Alfalfa, Purple vetch, Parsley, Red beet, Sugar beet	
6.0 – 15.0	Very Tolerant	Cotton, Asparagus	

Table 4: Chloride and sodium requirements of surface water for irrigation use.

Ion concentration (mg/L)	Sensitivity class	Corresponding crops	Test Method
Cl < 178; Na < 115	Sensitive	Almond, Apricot, Plum	APHA 4500-Cl^- B; APHA 3111-Na B
Cl = 178 – 355; Na = 115 – 230	Moderately Sensitive	Grape, Pepper, Potato, Tomato	
Cl = 355 – 710; Na = 230 – 460	Moderately Tolerant	Alfalfa, Barley, Corn, Cucumber	
Cl > 710; Na > 460	Tolerant	Cauliflower, Cotton, Safflower, Sesame, Sorghum, Sugar beet, Sunflower	

Table 5: SAR requirements of surface water for irrigation use.

SAR	Tolerance class	Corresponding crops	Test Method
2 – 8	Very Sensitive	Deciduous fruits, Nuts, Citrus, Avocado	APHA 3111-Na B, 3500-Ca B, 3500-Mg B
8 – 18	Sensitive	Beans	
18 – 46	Moderately Tolerant	Clover, Oats, Tall fescue, Rice	
46 – 102	Tolerant	Wheat, Lucerne (Alfalfa), Barley, Tomatoes, Beets, Tall wheatgrass	

4.3.

Heavy Metals

Table 6: Heavy metal requirements of surface water for irrigation use.

Parameter	Permissible Limit (mg/L)	Testing Method

Chromium (Cr)	≤ 0.1	USEPA 2000; APHA 3500-Cr B
Arsenic (As)	≤ 0.1	USEPA; APHA 3114 B
Lead (Pb)	≤ 5	APHA 3113 B
Mercury (Hg)	≤ 0.002	APHA 3112 B; APHA 3112 D APHA 3125 B
Cadmium (Cd)	≤ 0.01	APHA 3111 B; 3120 B; 3113 B; 3125 B
Nickel (Ni)	≤ 0.2	APHA 3111 B; 3113 B; 3125 B
Copper (Cu)	≤ 0.2	APHA 3500-Cu B
Zinc (Zn)	≤ 2	APHA 3500-Zn E; APHA 3500-Zn F
Manganese (Mn)	≤ 0.2	APHA 3111 B; APHA 3120 B; APHA 3125 B
Cobalt (Co)	≤ 0.05	APHA 3111 B; APHA 3113 B; APHA 3120 B; APHA 3125 B
Iron (Fe)	≤ 5	APHA 3111 B; APHA 3113 B; APHA 3120 B; APHA 3125 B; APHA 3500-Fe B
Uranium (U)	≤ 0.01	US EPA 900.0
Selenium (Se)	≤ 0.02	APHA 3114 B; 3125 B

4.4.

Pesticides

Table 7: Pesticide requirements of surface water for irrigation use.

Parameters	**Permissible limit (µg/L)**	**Testing methods**
2,2-DPA (Dalapon)	≤ 4	US EPA Method 552.2
Acrolein	≤ 100	EPA Method 8316
Amitrol	≤ 2	US EPA Method 527
Atrazine	≤ 10	US EPA Method 525.2; US EPA Method 544
Bromacil	≤ 0.2	EPA Method 507/508/525.2
Dicamba	≤ 0.006	US EPA Method 8151A, Method 555

Metolachlor	≤ 28	US EPA 525.3
Simazine	≤ 0.5	EPA Method 507/508/525.2

4.5.

Biological Requirements

Table 8: Biological requirements of surface water for irrigation use

Parameters	**Permissible limit**	**Testing methods**
E.coli (cfu/100 mL)	≤ 1000	Multiple tube (ISO 9308-1)
Fecal Coliform (cfu/100 mL)	≤ 1000	Multiple tube (ISO 9308-1)
Helminth Eggs (Egg/L)	< 1	Sedimentation and microscopic examination (APHA, 2017)

Annex A

(Informative)

Glossary of Terms

This glossary defines key terms used in the document to ensure clarity and consistent understanding among stakeholders.

A.1 Aquatic Ecosystem: A water-based environment that includes living organisms (such as fish, plants, and microorganisms) and the physical and chemical conditions that support them.

A.2 Dissolved Oxygen (DO): The amount of oxygen present in water, which is essential for the survival of aquatic life.

A.3 pH: A measure of the acidity or alkalinity of water on a scale from 0 to 14, with 7 being neutral.

A.4 Surface Water: Water found on the surface of the earth, such as rivers, lakes, reservoirs, and wetlands.

A.5 Threshold Limit: The maximum or minimum concentration of a parameter allowed in water to ensure it remains safe for a designated use.

A.6 Wetland: Areas of land where water saturation is the dominant factor controlling the environment and the associated plant and animal life, often acting as natural filters.

Annex B

(Normative)

Parameters – Sources and Effects

B.1 Physical Parameters

Parameter	**Common Sources**	**Effects on Irrigation**
Electrical Conductivity (EC)	Natural weathering of rocks, fertilizers, saline intrusion, industrial effluents (Hem, 1985; Chapman, 1996)	High EC leads to salt accumulation in soils; harms salt-sensitive crops (FAO, 1985)
Total Dissolved Solids (TDS)	Mineral dissolution, wastewater discharge, fertilizers, road salts (Hem, 1985; Crittenden et al., 2012)	Reduces water uptake by plants; contributes to salinization and nutrient imbalance (FAO, 2003)

B.2 General Chemical Indicators

Parameter	**Common Sources**	**Effects on Irrigation**
SAR	Natural weathering, seawater intrusion, industrial processes, water softener backwash.	High SAR causes soil dispersion (loss of aggregation), leading to surface crusting, reduced water infiltration, and erosion (Ayers & Westcot, 1985).
Dissolved oxygen	Diffusion from atmosphere, photosynthesis of aquatic plants and algae.	Not directly applicable. Low DO often indicates stagnation or high organic matter, which can clog systems.
pH	Natural CO_2 absorption, acid rain, mine drainage, industrial discharges, photosynthesis/respiration.	Affects nutrient availability in soil; extreme pH can damage plant roots and leaves (Ayers & Westcot, 1985).

B.3 Inorganic Chemicals

Parameter	Common Sources	Effects on Irrigation
Almunium (Al)	Natural mineral weathering, industrial discharges, mine drainage.	Can precipitate in soil at neutral pH, clogging drippers; toxic to some crops in acidic soils (Ayers & Westcot, 1985).
Boron (B)	Natural weathering (volcanic rocks), industrial discharges, cleaning agents, seawater.	The narrow margin between deficiency and toxicity makes it a primary concern for sensitive crops (citrus, avocados) (Ayers & Westcot, 1985).
Berylium (Be)	Coal combustion, industrial wastewater (electronics, aerospace), natural weathering.	Toxic to plants; water source should generally be avoided for food crops.
Sodium (Na)	Natural rock dissolution, sewage, irrigation return flow, detergents, road salt (UNEP, 2006; Allan & Castillo, 2007)	High sodium causes soil dispersion and reduced permeability, affecting crop yields (measured as SAR) (FAO, 1985; FAO, 1992)
Chloride (Cl^-)	Rock salt deposits, domestic wastewater, industrial discharges, irrigation return flow (UNEP, 2006; Chapman, 1996)	High levels can be toxic to crops and cause salinity in soils (FAO, 1985)
Fluoride (F^-)	Natural erosion, industrial discharge (fertilizer, aluminum production), water additive.	Toxic to certain sensitive crops (e.g., gladiolus, fruit trees) at relatively low concentrations via leaf burn (Ayers & Westcot, 1985).

B.4 Heavy Metals

Heavy Metal	Common Sources	Effects on Irrigation Use

Lead (Pb)	Battery manufacturing, mining, lead-based paints, fuel combustion, and old plumbing systems (Alloway, 2013; WHO, 2017)	Accumulates in soil and crops; causes phytotoxicity and enters the food chain (FAO, 2003)
Cadmium (Cd)	Electroplating, batteries, phosphate fertilizers, sewage sludge, and industrial effluents (Alloway, 2013; Jarup, 2003)	Extremely toxic to plants; reduces crop productivity and quality (FAO, 2022)
Chromium (Cr)	Tanning industries, electroplating, dyes, corrosion inhibitors (WHO, 2003; Shanker et al., 2005)	Cr^{6+} impairs plant growth and reduces yield; Cr^{3+} is less toxic and sometimes essential (FAO, 2003)
Mercury (Hg)	Gold mining, coal combustion, industrial discharge, medical waste (UNEP, 2013; Driscoll et al., 2013)	Contaminates irrigation water and accumulates in crops like rice; risk to food safety (FAO, 2022)
Arsenic (As)	Natural geological sources, mining, pesticides, and industrial waste (Smedley & Kinniburgh, 2002; WHO, 2011)	Absorbed by crops (esp. rice); long-term ingestion linked to cancer and organ damage (FAO, 2003)
Zinc (Zn)	Galvanized pipes, mining, fertilizers, and industrial effluents (Alloway, 2013; ATSDR, 2005)	Excessive Zn affects nutrient uptake in plants and may accumulate in edible tissues (FAO, 2022)
Copper (Cu)	Mining, plumbing, pesticides, algicides, and industrial discharge (USEPA, 2009; ATSDR, 2004)	High Cu inhibits root elongation and nutrient uptake; can cause phytotoxicity (FAO, 2022)
Nickel (Ni)	Electroplating, fossil fuel combustion, steel manufacturing, industrial runoff (WHO, 2005; Alloway, 2013)	Accumulates in soil and crops; reduces plant growth and nutrient absorption (FAO, 2003)
Iron (Fe)	Natural weathering, mining, industrial	Not harmful but may stain irrigation

	discharge, corroded pipelines (Chapman, 1996; WHO, 2003)	systems and affect soil texture (FAO, 2003)
Manganese (Mn)	Natural geological sources, mining, steel production, industrial runoff (WHO, 2011; Alloway, 2013)	High levels stain equipment and interfere with nutrient uptake in crops (FAO, 2003)
Cobalt (Co)	Mining and smelting, industrial effluents, sewage sludge, and application of phosphate fertilizers (Alloway, 2013; ATSDR, 2004)	Essential for ruminants (vitamin B_{12}) but phytotoxic at high levels; causes iron deficiency (chlorosis) in plants and accumulates in forages (Kabata-Pendias, 2011)
Uranium (U)	Natural geological deposits, phosphate fertilizers, mining activities (uranium and gold), and coal combustion (WHO, 2011; IAEA, 2014)	Accumulates in plant roots with limited translocation; primarily a radiological/chemical risk to human health via ingestion of contaminated crops and water (FAO, 2022)
Selenium (Se)	Natural geological sources (seleniferous soils), mining, coal combustion, and agricultural drainage water (Alloway, 2013; USEPA, 2014)	Essential in trace amounts but toxic at elevated levels; causes bioaccumulation in crops (e.g., wheat, corn), leading to selenosis in humans and livestock (FAO, 2003)

B.4 Pesticides

Pesticide	**Type**	**Common Source**	**Effect on Irrigation Use**
Atrazine	Herbicide	Used in maize and sorghum farming; enters water through agricultural runoff (Giddings et al., 2005;	Residues accumulate in soils; reduce microbial diversity and affect crop health (FAO, 2022)

		UNEP, 2022)	
Metolachor	Herbicide	Agricultural herbicide runoff (corn/soybean fields).	Can persist in soil and affect subsequent rotational crops; detected in groundwater used for irrigation.
2,2-DPA (Dalapon)	Herbicide	Used for weed control in crops like potatoes and sugarcane; runoff from treated fields (UNEP, 2022)	Breaks down in soil but can leach to groundwater; impacts soil microbes and sensitive plants (FAO, 2003)
Acrolein	Herbicide/ Aquatic	Applied to control aquatic weeds in irrigation canals and rice fields; volatilizes into water (US EPA, 2020)	Highly toxic to aquatic life; short persistence but high mobility in water systems (FAO, 2010)
Amitrol	Herbicide	Non-selective weed control in non-crop areas and vineyards; leaches easily through soil (UNEP, 2022)	Persistent in groundwater; disrupts photosynthesis in crops and reduces soil enzyme activity (FAO, 2005)
Bromacil	Herbicide	Used on citrus, grapes, and non-crop areas; high water solubility leads to leaching (US EPA, 2017)	Long soil half-life; contaminates aquifers and affects non-target vegetation (FAO, 2012)
Dicamba	Herbicide	Applied to soybeans, cereals, and pastures; volatile drift to nearby	Moderate persistence; can damage broadleaf crops via drift and root uptake from

		fields (UNEP, 2022)	irrigation (FAO, 2008)
Simazine	Herbicide	Used in orchards, vineyards, and maize; persistent and mobile in soils (UNEP, 2022)	Accumulates in aquifers; inhibits photosynthesis in aquatic plants and crops (FAO, 2007)

B.5 Biological Parameters

Parameter	**Common Source**	**Effect on Irrigation Use**
Escherichia coli (E. coli)	Fecal contamination from humans, livestock, wastewater, and surface runoff (Cabral, 2010; WHO, 2003)	Indicates microbial contamination risk to edible crops (WHO, 2006)
Fecal Coliforms	Soil, decaying vegetation, untreated wastewater (Leclerc et al., 2001)	High levels indicate unsuitability for irrigation of fresh produce (FAO, 1992)
Helminth Eggs (e.g., Ascaris)	Untreated wastewater, open defecation, livestock waste (Mara & Feachem, 1999; WHO, 2006)	Major concern in wastewater irrigation; infect vegetables and soil (FAO, 1992)

Annex C

(Informative)

C.1. Definition of tolerance for Boron

Boron concentration ranges in irrigation water are classified by mg/L levels, with corresponding crop tolerance classes indicating sensitivity to boron toxicity. These thresholds define maximum permissible levels without significant yield reduction, varying by crop species

- **Very Sensitive**: Crops suffer yield losses even at trace boron levels; suitable only for pristine, low-boron water.
- **Sensitive**: Narrow tolerance range; minor exceedance causes rapid toxicity in fruits, nuts, and legumes.
- **Moderately Sensitive**: Moderate buffer against elevated boron; vegetables show initial stress but sustain partial yields.
- **Moderately Tolerant**: Handle doubled sensitive thresholds; grasses and brassicas perform well under moderate irrigation boron.
- **Tolerant**: Withstand higher loads; beets and forages maintain productivity in semi-saline conditions.
- **Very Tolerant**: Highest resilience; fiber and perennial crops thrive where boron is problematic for others.

C.2. Definition of tolerance for chloride and sodium

Sensitivity classes categorize crops by tolerance to Cl and Na accumulation, which disrupts plant water uptake and causes foliar damage.

- **Sensitive**: Crops show yield loss even at low levels; stone fruits require pristine water.
- **Moderately Sensitive**: Handle moderate buildup; solanaceous crops tolerate brief spikes with leaching.
- **Moderately Tolerant**: Withstand elevated ions; grains and legumes sustain yields under saline conditions.

- **Tolerant**: High resilience; oilseeds and fibers thrive where others fail

C.2. Definition of tolerance for SAR

SAR (Sodium Adsorption Ratio) in irrigation water measures sodium hazard relative to calcium and magnesium, where higher values increase soil alkalinity and reduce permeability, harming crop roots and yields. Tolerance classes rank crops by resilience to sodium-induced soil dispersion and infiltration issues.

- **Very Sensitive**: Prone to rapid yield loss from minor sodium buildup; tree fruits and nuts demand low-SAR water.
- **Sensitive**: Limited buffer; legumes show stress without frequent leaching.
- **Moderately Tolerant**: Sustain yields in moderately sodic conditions; grasses and cereals benefit from amendments.

Tolerant: High resistance; forages and roots thrive in high-SAR water with coarse soils

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