into their recipients (Larsson et al. 2007; Li et al. 2008; Larsson 2014; Gothwal and Thatikonda 2017). In addition, these treatment plants seem to be breeding grounds for resistant bacteria that subsequently are released into the environment (Johnning et al. 2013; Marathe et al. 2013). The antibiotic residues released from production do in turn affect local bacterial communities and select for high levels of antibiotic resistance (Li et al. 2008; Kristiansson et al. 2011; Bengtsson-Palme et al. 2014b; González-Plaza et al. 2017). Much data also points toward that such conditions select for a general enrichment of mobile genetic elements that can be shared between bacteria, and thereby enrich resistance genes against a whole range of antibiotics, and consequently also render bacteria generally more multiresistant (Bengtsson-Palme et al. 2014b; Pal et al. 2016; Bengtsson-Palme 2018). Even if this selection does not happen directly in human pathogens, opportunistic pathogens with extensive resistance phenotypes have been isolated from such environments (Johnning et al. 2013; Marathe et al. 2013). Given the enrichment of genes responsible for moving genes between bacteria in the same environments, it is not far-fetched to imagine that such resistance traits may be transferred to human pathogens after dispersal back to a human host (Bengtsson-Palme et al. 2018b).

24.3.4 Environmental Antibiotic Resistance is a Poverty Problem

Worldwide, 2.4 billion people still do not have access to improved sanitation, and nearly one billion people still practice open defecation (United Nations World Water Assessment Programme [WWAP] 2017) (Figure 24.1). This results in a major health risk for the local population if human pathogenic microorganisms enter the environment and potentially acquire antibiotic resistance genes from environmental bacteria via horizontal gene transfer. In addition, resistance genes end up in the environment and might be incorporated by and spread within the allochthonous microbial community and, under optimal conditions, later be taken up by human pathogenic species. The permanent and direct contact of people with untreated wastewater additionally increases the risk of infection with antibiotic-resistant human pathogens.

If one projects the locations of wastewater treatment plants and the respective applied treatment technologies onto a world map, the absence of a well-functioning wastewater treatment system overlays with low income, i.e. environmental antibiotic resistance is largely a poverty problem (Figure 24.1). Whereas in high-income countries about 70% of the municipal and industrial wastewater is currently treated, only 8% of the wastewater generated in developing countries undergoes treatment in any way. Globally, 80% of the total wastewater is directly discharged into receiving water bodies. Thinking further, it becomes clear that the lack of a functioning sanitary system in poor countries has effects on the global scale. It is possible to fly around the world within less than two days, and due to globalization, air traffic becomes increasingly important. As a result,